Hochstetter, "With the beginning of volcanic action, by which the tuff-cones were formed, a slow and gradual upheaving of the whole isthmus seems to have taken place, so that the latter eruptions"—by which the scoria-cones were formed—"were supramarine."

There remains one question of interest which I should like to notice—the question of the age of these volcanoes. On this point we may be certain that, although the last of them was probably extinct before the advent of the Maori, still they are of comparatively modern date. They distinctly overlie all other formations in the neighbourhood, being the latest or surface-deposits, and containing, mingled with their materials, fragments of the Waitemata beds upon which they rest. The fresh and recent appearance of the scoria and lava, the unaltered angle of slope of the sides of the hills, the fact that the lava-streams have everywhere followed valleys and depressions in the surface of the land which exist at the present day, all show that these volcanoes are of geologically recent date, and that since the cessation of volcanic activity the general contour and surface-features of the land have remained unaltered. We conclude, therefore, that this activity dates from Pleistocene, if not later or recent times.

Art. XXXII.—*On the Prospects of finding Workable Coal on the Shores of the Waitemata.*

By James Park, F.G.S., Lecturer, Thames School of Mines.

[*Read before the Auckland Institute, 22nd June, 1891.*]

The recent reported discovery of a thin, irregular seam of coal in the cliffs near Northcote has again directed attention to the probable existence of workable coal in the vicinity of the City of Auckland. The great economic importance of this question has long engaged the attention of the Director of the New Zealand Geological Survey; and during the past ten years a number of surveys have been undertaken by the officers of his department with the view of collecting sufficient data to definitely determine the relation existing between the Waitemata beds and the New Zealand coal-bearing series.

In the years 1879, 1880, and 1881 Mr. Cox, late New Zealand Assistant Geologist, examined the country extending northwards from the Auckland isthmus to Whangarei on the east coast and the Upper Kaipara on the west. He arrived at the conclusion that the Waitematas, as typically developed

at Orakei Bay and Fort Britomart, were unconformable to, and had no connection with, the brown-coal measures of Drury and the Lower Waikato basin. In 1885 and 1886 I re-examined the same country, and also made a close and detailed survey of the shores of the Hauraki Gulf from Auckland to the Maraetai Range. The result of my observations tended to show that no unconformity existed from the top of the Waitematas to the base of the Papakura series; and subsequent surveys by Mr. McKay, F.G.S., the present Assistant Geologist, have shown that the Papakura beds rest quite conformably on the brown-coal measures of the Waikato and Drury areas. The fact has therefore been established, by actual survey and observation, that the Waitemata beds are conformable to and belong to the New Zealand coal-series—an opinion which has always been maintained by Sir James Hector.

It may be as well, before pursuing this subject further, to shortly inquire into the physical conditions considered necessary for the formation of coal. By the geologists of the early part of this century it was believed that workable true coal could only be found among a certain class of shales and sandstones of the Palæozoic or Primary period, to which the age-name Carboniferous had been affixed; and it may be as well to note here that this conclusion was fully sustained by their experience of the coal-measures of Great Britain, continental Europe, and North America, all of which were found to belong to this period. But the many brilliant discoveries of the past forty years have led to a remarkable evolution of thought and theory in every branch of knowledge, and in none is this seen more conspicuously than in the science of geology. True coals of superior quality have been found in the Jurassic and Triassic rocks of India and New South Wales, and in New Zealand in rocks that belong to the base of the Tertiary period, but which possess in some places a Secondary *facies*, and hence have been called Cretaceo-tertiary in age.

Thus it is seen that there is interposed between the Carboniferous coals of Britain and the Cretaceo-tertiary coals of New Zealand the whole of the Secondary and a part of the Primary periods, representing an immensity of time of such infinite duration as to defy the comprehension of our finite minds. This wide lapse of time renders it easy to explain the great geological differences that exist between our own and the Old-World coals. Perhaps the most marked distinction lies in the character of the vegetation of which each is composed, for, while the European coals are mainly composed of the remains of a flora belonging to the cryptogamic kingdom, truly characteristic of the Palæozoic period, the New Zealand coals are composed of the remains of a varied forest vegetation which

everywhere marks the advent of the Tertiary period and the luxuriant flora of the present time. In the forests of our coal period there flourished two species of the kauri, which at that time grew all over New Zealand; three species of the beech, so commonly and erroneously known throughout the colony by the settlers' name of "birch;" also the oak, laurel, myrtle, heaths, palms, ferns, grasses, &c.

It is now recognised by geologists that coal could form at any period of the earth's history if the necessary conditions existed, and it is probable that these conditions have continued the same through all geological time. They were—(1) a humid, temperate climate, favouring the growth of a dense vegetation; (2) flat or gently-sloping low-lying areas, favourable for the accumulation of thick deposits of vegetable humus and peaty matter; and (3) a stationary, or nearly stationary, state of the land, to permit a long-continued and uninterrupted growth of vegetation.

In New Zealand our coal-areas are mostly littoral, of small extent, and patchy, characteristics resulting principally from the insular and mountainous nature of the country in older Tertiary times. Where the sides of the valleys were steep and the hills met the sea it was impossible for the remains of vegetation to accumulate to any extent; and this explains the somewhat anomalous fact that the coal-measures do not always contain coal. The steepness of the land during the coal period is also accountable for the noticeable fact that our coals often thin out towards the dip, and, when lying near the old rocky floor, are usually found to conform with the contours of its surface.

But whether the forests which formed the coal grew in soils lying directly on the old basement rock, as we find is the case with those of the Auckland Provincial District, or on the upper surface of areas reclaimed from the sea, as is the case of the forests which formed the Shag Point and West Coast coals of the South Island, it happened that after a long period of rest, permitting the accumulation of thick deposits of vegetation, the land began to sink slowly, and in course of time the vegetation became covered by fluviatile clays and sands, generally containing fragments of leaves and other plant-remains derived from the vegetation which continued to flourish on the higher portion of the dry land which had not become submerged.

As the land continued to sink the fluviatile or estuarine beds became covered by blue clays and greenish-coloured sands, containing the imbedded remains of the numerous Mollusca, crustaceans, corals, whales, sharks, and other life which teemed in the seas of those times. In a few instances in the north of Auckland coalfields true marine beds containing a varied molluscous life appear close to the roof or upper

surface of the coal. It is difficult to look back into these old Eocene times and judge the conditions which prevailed in every isolated nook during the formation of the coal; but examining the geological records—the fossil life preserved in the rocks—we arrive at the conclusion that in these exceptional cases the matter which afterwards formed the coal accumulated in narrow, sheltered valleys adjacent to the sea, in places where after its gradual submersion it was not subject to the action of streams or rivers laden with sand or mud or other detritus.

Again, pursuing the order of events which followed the deposition of the coal, we find that the blue clays and greensands were followed by shelly and coralline sands which now form the well-known Whangarei, Waipa, Raglan, Mokau, and Oamaru limestones. These are simply local names for the same limestone which is perhaps one of the most marked, constant, and characteristic geological horizons in New Zealand, and seems to form the natural close of the coal-formation. Now, this limestone is followed throughout New Zealand, quite conformably, by a great series or succession of sands and clays, which, in the classification of the New Zealand Geological Survey, possesses the generic name "Grey Marls," or "Waitemata series." These sands and clays are typically developed on the shores of the Waitemata, which has given its name to the rocks of this period throughout New Zealand. The Waitematas, as seen at Fort Britomart or the Calliope Dock, consist of rapidly-alternating layers of clays and soft sandstones. The presence in these of numerous plant-remains, and sometimes thin irregular streaks of coaly matter, together with the almost entire absence of true marine beds, clearly point to the prevalence of fluviatile conditions during their deposition.

The sequence of events which we have traced in order to show the relation of the coal-measures and the Waitemata beds may be more graphically shown as follows:—

Cretaceo-tertiary formation.

1. Waitemata sands and clays.
2. Whangarei or Oamaru limestone.
3. Marly clays and greensands of marine origin.
4. Fireclays and coal with grits and conglomerates.
5. Basement rock.

The Waitemata beds occur at the top of the Cretaceo-tertiary formation, while the coal occurs at the base, the two being separated by two great geological horizons. This in itself might be taken as strong evidence that no coal of a workable nature would be found in the Waitematas; but we have seen that coal could form at any geological period if the necessary conditions existed. We, however, receive little

encouragement from this source, as the rapidly-altering character of the Waitemata deposits would tend to show that dynamic forces were at work during this period, causing frequent oscillations of the land, thus preventing the accumulation of sufficient vegetable matter at any period to form workable coal-seams.

Workable seams of coal exist on the flanks of the Hunua Range, and dip in the direction of the Waitemata, but it is doubtful if they reach as far as Auckland, and, if they do, they would certainly be found at a great depth—probably not much under 800ft. or 1,000ft., judging from the thickness of strata which is known to exist between the Waitematas and the coal at other places.

Auckland stands in the centre of a great synclinal or trough, and the depth to be penetrated there would be greater than at any other point. Towards Howick on the one side and Riverhead on the other the depth of strata to be passed through gradually decreases until, on the flanks of the Hunua and Maraetai Ranges, the coal crops out on the surface. In the case of the upper reaches of the Waitemata, wherever the old floor or basement rock is found at or near the surface, and whether it is composed of hydraulic limestone or slaty shales, a careful search should be made for indications of coal, for it was on such old floors that the coal vegetation grew and flourished in the older Tertiary times.

If, therefore, there is a probability of coal on the shores of the Waitemata, it will be found in the upper reaches, in the direction of Riverhead, where the edges of the lower members of Cretaceo-tertiary formation are upturned against the basement rock.

Art. XXXIII.—*On the Occurrence of Native Zinc at Hape Creek, Thames.*

By James Park, F.G.S., Lecturer, Thames School of Mines.

[*Read before the Auckland Institute, 24th August, 1891.*]

Last month Mr. George Manton, a settler on the right bank of Hape Creek, discovered in his garden a heavy metallic substance, which he handed to me for identification. This substance proved on examination to be metallic zinc, of great purity, and coarsely crystalline structure.

In reply to my inquiries Mr. Manton informed me that when removing a quantity of gravel and boulders which he had excavated from the well in his garden he was attracted