

CAPE CAMPBELL-WARD DISTRICT.

The country between Cape Campbell and the Flaxbourne River was superficially examined by Hutton in 1873 (4*, p. 27), and in somewhat greater detail by McKay several years later (7, pp. 185–91). Subsequent visits by geologists have been of very brief duration. Although McKay's later reports contain some additional information, the geology of the district is far from being sufficiently elucidated. The rocks present, according to McKay, range in age from Cretaceous to Pliocene, and consist of igneous breccia, sandstone, limestone, mudstone, conglomerate, &c. By adding Pleistocene and Recent deposits the following classification is reached:—

Formation or Series.	Composition, &c.	Approximate Age.
	Gravels, &c., of river-flats, terraces, and raised beaches	Recent and Pleistocene.
Great Marlborough Conglomerate ..	Conglomerate east of Lake Grassmere ..	Pliocene (?).
Awatere beds	Calcareous mudstone, &c.	Miocene.
Grey Marl	Calcareous mudstone and fine sandstone ..	Early Tertiary (?).
Waipara	Limestone, flint, sandstone, igneous breccia, conglomerate, &c.	Cretaceous (possibly in part Early Tertiary).

For many details concerning the various rock formations the reader may be referred to McKay's reports. His sketch-map published in 1877 requires considerable corrections, but in order to make these a detailed survey is necessary. The following remarks, supplementing McKay's information, may here be given. The Flaxbourne breccia does not consist wholly of fragments of igneous origin, but also contains a considerable proportion of sedimentary rocks. Much of the material is water-worn, and there are small bands of dark-grey mudstone interbedded with the coarser beds.† Calcite is abundant in vesicles of volcanic rock fragments, as a cement, and as lenticular patches. In places the calcareous material is decidedly phosphatic. These observations confirm a verbal statement made by Dr. J. A. Thomson to the writer that the breccia probably passes northward into an ordinary conglomerate. It occupies a much narrower area than that shown on McKay's map, for its western boundary is some distance east of Lake Elterwater.‡

The limestone of the Cape Campbell-Ward district, together with the flinty concretions and lenses in which it abounds, may conveniently be hereafter referred to as the Amuri limestone, the name in common use for this portion of the Waipara Series. Owing to the combined effects of faulting and folding it has a more erratic distribution than that shown on McKay's map. In particular a belt of flinty facies trends along the coast north and south of the Flaxbourne River. Appearances favour the opinion that there are two distinct bands of limestone, separated by a thick bed of sandstone, but further examination is necessary before this view can be established. The interstratified greensand beds mentioned by McKay (7, p. 188) are of small thickness. They are best seen at the outcrop of Amuri limestone on the shore east of Lake Grassmere, where, however, owing to faulting, only the uppermost limestone horizon is represented.

The calcareous grey mudstone, or in places fine sandstone, known as the Grey Marl, has a great development in the Cape Campbell district. It forms cliffs from the Amuri limestone outcrop mentioned above to Cape Campbell, and thence southward along the coast. Since the breadth of exposure at right angles to the strike is almost three miles, and the dip in most places is 40° or over in a consistent easterly or south-easterly direction, McKay's estimated thickness of 8,000 ft.§ (7, p. 189) seems reasonable, provided there is no fault in the section. Faults, however, are present, and though their effect cannot be definitely stated, a considerable reduction of McKay's estimate may be safely made. Another factor that may enter into the question is the possible presence of Awatere beds in the upper part of the supposed Grey Marl section.

The Awatere beds of the district lithologically resemble the Grey Marl, and can be certainly separated from it only by their fossil contents. They are less indurated than the average sample of Grey Marl, and consequently even more liable to slump. The greater part of their eastern boundary as shown on McKay's map of 1877 ought to be extended farther to the east, particularly in the neighbourhood of Lake Elterwater.

The Great Marlborough or post-Awatere Conglomerate was found by the writer to occur between Lake Grassmere|| and Cape Campbell near the position indicated by McKay, but somewhat farther to the eastward. The exposure is much narrower than shown by McKay's map of 1877, and probably does not extend so far to the south. His map of 1890 (16, opp. p. 96), though on a much smaller scale, is more correct in these respects. The character of the conglomerate, except that no boulders over 2 ft. in diameter were seen by the writer, is precisely as described by McKay, and his estimated thickness of not less than 200 ft. is approximately correct, or, at least, not over the mark. Curiously enough, in 1877 McKay, as shown by his section BB (7, opp. p. 188), misjudged the stratigraphical relations of the conglomerate, so that his estimate of the thickness must have been a mere guess. Instead of lying on the upturned edges of the other formations, it is involved equally with them in a great fault-zone, and has an almost vertical

* This and other numbers similarly enclosed in parentheses refer to the list of literature at end of report.

† McKay mentions interstratified beds of green sandstone (7, p. 187).

‡ In December, 1915, Lake Elterwater was perfectly dry.

§ In Sixth Ann. Rep. G.S., C.—9, 1912, p. 9, this estimate is misquoted as 12,000 ft.

|| Lake Grassmere was dry at the time of the writer's visit in December, 1915, although its bed is below high-water mark.