

Dr. Macintosh Bell, in his "Geological Survey Report on the Franz Josef Glacier," says, "It is noteworthy that the West Coast glaciers descend, in general, to much lower altitudes than those of the East Coast." He then instances the Tasman (2,354 ft.), Mueller (2,550 ft.), Hooker (2,882 ft.), Fox (670 ft.), Franz Josef (692 ft.). On this assumption he drew certain conclusions. As a matter of actual fact, the glaciers on the west do *not* "in general" descend to any lower level than those on the east—for instance, Balfour (2,308 ft.), Horace Walker (3,800 ft.), Douglas (4,000 ft.), McKerrow (4,200 ft.), La Perouse (about 3,200 ft.). It is true that the Franz Josef and Fox descend to phenomenally low altitudes, but they are unique in this respect not only in New Zealand, but in the world, considering their latitude; therefore they cannot be taken as examples of west coast glaciers, for their conditions are exceptional even on the west coast, and I propose to deal with them later.

Not only Dr. Bell, but several other scientific writers in the past, have theorized to account for the supposed greater glaciation on the western side of the alps, and have assumed that the much greater rainfall on the west would account for the difference. Here again I make bold to join issue and say that *within the area of glaciation* the precipitation is not very much greater on the western side than on the eastern, because within four or five miles of the divide the moist westerly winds precipitate almost as much moisture on the one side as on the other. But, quite apart from this, I say there is no need to account for what does not exist, because I cannot agree that there is more glaciation on the western side of our alps as a whole. It is true that there are more separate glaciers on the west, but they do not compare in size with those on the east. They are, in my opinion, *due not to a greater snowfall, but to the configuration of the country.*

Dr. Bell, in support of this theory, instances the *névé* fields on the Fox and Franz Josef as being "unsurpassed in the alps in extent" (see Geological Survey, 1910, report on Franz Josef Glacier). This is quite true, but I submit it is not a greater snowfall so much as the formation of the country which accounts for these huge snow fields. They are really great basins which *catch and hold all the snow that falls*, whereas on Tasman the mountains are too steep to permit of similar accumulations. Much of the snow dissipates in the form of avalanches. For the same reason the great ice-fields at the head of the Tekapo Valley are far in excess of those on the western slopes in that locality.

If all districts are examined from Mount Aspiring to Arthur's Pass it will be at once seen that there is little support for the statement that the glaciation is heaviest on the west. Any difference can be accounted for by the configuration of the mountains, and no other explanation is necessary.

*Ancient Glaciers* (on the authority of several distinguished geologists such as Haast, Hutton, and others).—It may be taken that during the period of maximum glaciation known as the Glacier Period an ice-sheet covered much of the centre of the South Island; there is ample evidence of this. This ice-sheet spilled over wherever an opening occurred, and the ice would flow down the steeper slopes towards the sea. To quote Dr. Bell, "In the Pleistocene period the ice deployed on to the narrow coastal plain of Westland and formed a vast piedmont ice-sheet, above which the isolated peaks and ridges rose as lonely Nunataks." Haast estimates that this great ice-sheet went fifteen miles out to sea in some places. Judging by the clearest evidence which Douglas and I observed in the various valleys, the ice in places was 4,500 ft. thick and practically covered the whole area included in these reserves. The ice-lines in the upper valleys over the whole area of Karangarua and Twain are clearly to be seen at 5,800 ft., being fully 3,000 ft. above the present floor of the valley. On Ryans Range I found a very distinct line of large boulders poised on the steep hillside at over 4,000 ft. above sea-level which were unquestionably an old lateral moraine left by the ice. From this and a great deal of other evidence, too long to set out in this paper, we concluded that at this remote period the only peaks or ice-free rocks showing in the area covered by these reserves were a small portion of the Karangarua, Ryans, Copland, Craig's, and Fritz Ranges, rising, as Dr. Bell says, "as lonely Nunataks" in a field of ice. The Karangarua main valley is a perfect example of a valley which was once completely occupied by a large glacier, which I am satisfied came from the central ice plateau over the Karangarua Saddle to the west. When the ice began to recede this branch would be cut off from its main source of supply at the Karangarua Saddle, which is 5,600 ft. above sea-level, and, having no high peaks near it from which to maintain its size, it would suddenly and rapidly shrink, leaving this great valley in its present state.

It would unduly prolong this paper to go into further details on this matter of ancient glaciers. Any one interested can refer to my book "Pioneer Work" and to several reports by Douglas in the Survey reports from 1892 to 1896, which contain not only our conclusions, but the evidence, on which they were based. The latter, at any rate, is valuable, even if our conclusions are open to argument.

*Glacier Variations.*—Our glaciers are undoubtedly steadily receding. I can see considerable shrinkage on the Tasman Glacier, its tributaries, and immediate neighbours, in the course of the last forty-one years. The retreat of the glaciers at the head of the Twain and Landsborough Rivers since I examined them in 1894 is very remarkable (see Figs. 5 and 6). This retrocession seems to accord with the general climatic conditions of the world, for the Canadian and other alpine glaciers show even greater retreat. If any cases of temporary advance exist, the variation is very slight, except in the case of the Franz Josef, which since 1893 has shown periods of steady retreat, followed by very rapid recovery, not only at the terminal face, but in the depth of the ice over the whole trunk. As lately as 1928–29 the whole glacier advanced a considerable distance and recovered much ground vacated by the ice. It also rose considerably along the sides.

During these advances the ice swept away vegetation which had sprung up since its last retreat. Observation proves, however, that each advance falls short of the previous one; thus general retrocession is going on here as elsewhere. Unfortunately, owing to the want of co-ordination between the Geological and the Survey Departments, the elaborate system of marks and cairns erected, and *officially recorded* by Douglas and me in 1893 for checking future variations, were entirely