

seen many moraines in progress of formation; but the Blue Spur deposit does not resemble any of them. The partly or fully water-worn shingle in the beds of the larger rivers of Westland, from the Teremakau to the Haast, will show the manner in which the Blue Spur deposit was formed. The Horse Range deposit, being of greater extent, thickness, and generally of coarser material as respects the more angular detritus forming the greater bulk of the deposit, has a far better claim to be regarded as having been due to glacier-action or deposited as a moraine; but the material is somewhat regular in its occurrence, and never of great size, and might, all of it, have been brought from the neighbouring schistose area west of the Shag Valley by the action of a considerable and powerful torrential river.

These gravels, therefore, are nothing more than old river-gravels, more or less rounded, of the period to which they belong, and, as part of a great system of gravel-deposits, the portions which have been described have escaped denudation and rearrangement owing to their peculiar position, and the rate at which the sea invaded the land during the subsidence which followed the formation of the coal-bearing part of the Cretaceo-tertiary series.

It has been mentioned that there are in the Nevis Valley schistose breccias resembling the Blue Spur deposit; but there are doubts as to the actual age of these, and notice of them will be deferred till dealing with the "newer breccia conglomerate."

*Quartz Drifts.*—Towards the production of these the first stage would necessarily be the formation of rough schistose shingle resembling the mountain-creek rubble, and the river-gravels of the present time, and, without question, the quartz drifts have largely resulted from the further pounding of the breccia conglomerates. This result, as may be seen in the great accumulations of quartz sands and coarser drifts, has undoubtedly been effected by the agency of wave-action, either of the sea or on the shores of extensive inland lakes, there being no rivers in New Zealand at the present time that do, or apparently can, produce pure quartz gravel by current-action along its bed. Having this possibility in view, the writer carefully noted the gravels of the Molyneux, from the Beaumont to the outlets from Lakes Hawea, Wanaka, and Wakatipu, and nowhere was anything noted leading to the belief that the quartz grits have been so produced. Quartz sands and quartz drifts are, however, found on the shores of Molyneux Bay, where no local stream carries rubbly material from a near distance or readily-denuded cliffs at present capable of producing quartz drifts. Subangular quartz drifts may, however, be formed in the manner already described in this report (see page 8), where it is stated that such drifts are forming on a small scale along some of the tributaries of the Upper Waitahuna, and also where it is stated that the quartz drifts of the Upper Waipori Valley may have been formed in the same way. However, owing to the peculiar conditions, deposits of quartz drift so formed can have but a limited extent and importance.

Along the entire eastern and southern seaboard of Otago, and for a considerable distance inland, the quartz drifts have been formed by the action of the sea. The rivers conveyed the unsorted mixture of slate and quartz to the shore-line, where it was reduced to nearly pure quartz.

From fifty miles up the Waitaki Valley, along the foot of the Kurow and Mount Domett Ranges to the Livingstone Goldfield, all the quartz sands are directly followed by marine fossiliferous beds; and from the same dish of stuff taken from the greensands overlying the quartz drifts of the Maraewhenua Goldfield, sharks' teeth, sea-shells, and gold can be obtained. The same conditions obtain between Big Hill and the gorge of the Kakanui River, and along the whole eastern flanks of the Kakanui Range to Trotter's Creek and the Horse Range. South of Palmerston, almost the whole of the upper watershed of Pleasant River is covered by quartz drift, in the higher beds of which marine fossils are to be found; and from Hummock Side, westward and southward, the quartz drifts are marine to Nenthorn Creek and Taieri Ridge on the one hand, and to Silverstream and Mullocky Gully on the other. In the northern part of eastern Otago the quartz drifts are marine to a little west of Naseby, probably to the water-divide between the Ewe Burn and Wether Burn. At the Government dam—the distributing dam of the Mount Ida Water-race—an abundance of marine fossils are to be obtained from beds immediately overlying the quartz drifts, and the deposits at Hamilton's are regarded as being of the same age and of like origin. Hyde, Fullerton's, and Station Hill should also, with some other localities, be included with the drifts that were immediately followed by marine beds. There is a possibility that within Strath Taieri, and also along the Taieri River, near the mouth of Nenthorn Creek, the grits are overlain by, or otherwise associated with, beds of shale and lignite-seams that have originated on land and in fresh-water lakes. South of the Taieri the western limit of the marine beds may never have reached beyond Fortification Hill, and thence it would extend into what is now the Tuapeka watershed, and, in the southern part of the district, reach as far north as Tapanui, Waikaka, and Switzer's. The second area of quartz drifts, occupying central Otago, must be regarded as of fresh-water origin. This occupies the Wether Burn, Ida Burn, and Pool Burn Valleys, and the whole of Manuhierikia Valley; and the Molyneux Valley, from the foot of the gorge near Coal Creek, Roxburgh, to Lakes Hawea and Wanaka, including in this the valleys of the lesser streams, such as the Fraser River and the Bannock Burn. The western limit of this area of fresh-water deposit is the western sides of the Nevis and Cardrona Valleys. West of the Nevis and Cardrona watersheds there are no quartz drifts till the line from Bob's Cove, on Lake Wakatipu, to Skipper's Creek, on the Shotover, is reached. This, again, gives evidence of having been laid down in such a position that it was immediately and conformably followed by marine beds. From the beds immediately overlying the quartz drifts in this line abundant evidence of marine life is to be obtained. There is thus a central northern area of fresh-water deposits surrounded by a much larger area to the east, south, and west, which is undoubtedly, in the beds that immediately follow the quartz grit or drift, of marine origin.

The section from Livingstone to the limestone table-land on the south side of the Maraewhenua River may be taken as sufficient to show the age of the beds and their relationship to other