detailed treatment is accorded to the Malmesbury rocks of Robertson and Ashton, and a petrographical description is given of the large granite intrusion of Wolve Kloof, Robertson.

The distribution and characters of the rocks of the Cape and Karroo Systems are only dealt with in so far as they throw light on the principal subject of the paper; but a fairly full description is given of the occurrences of Enon Conglomerate, which is shown to occupy a series of isolated basins, arranged along an east-and-west line, and to lie with a strong discordance upon all the older rocks. After a careful examination of the ground, it is concluded that the Enon Conglomerate does not overlap the Worcester–Swellendam Fault, as indicated in the official maps; and that conglomerate does not appear to contain any fragments of the Malmesbury rocks, which cannot therefore have been exposed when it was formed.

After a careful discussion of all the available evidence it is concluded that the Worcester-Swellendam Fault, which has a maximum throw of probably 10,000 feet, is in great part of post-Cretaceous age, although there are indications of earlier movement along the same line of fracture. From a study of the dominant trend-lines of South-Western Cape Colony it is concluded that the district in question is situated at or near the central line of the syntaxis of two great sets of folds at right angles, which have assumed a fan-shaped arrangement in plan, and that the great fault is a line of fracture and subsidence running transversely across these lines of folding. The folding and the faulting are clearly phases of one general series of events, and the faulting probably resulted from a diminution or even reversal of the pressure which had previously given rise to the folding.

Baron Ferencz Nopcsa, jun., then gave some account of the Geology of Northern Albania. He said that he had examined the greater part of the Province of Scutari in Western Turkey, and recognized three distinct structural units: namely, the North Albanian platform, the folded Čukali, and the eruptive region of Merdita. In the first region Mesozoic limestone of all periods predominates; in the second region Mesozoic radiolarian chert is found; while in the third region Mesozoic clastic rocks, volcanic tuffs, and eruptive masses are abundant. The first and third units are not folded, but are, at least in part, overthrusts from the north and south respectively above the second (intermediate) unit, which is strongly folded. In Northern Albania Upper Carboniferous and Permian rocks are also distinguishable, and there is an Eocene Flysch.

CORRESPONDENCE.

THE HIGH-LEVEL GLACIAL DRIFT AND THE LAND-ICE HYPOTHESIS.

Sir,—In your January number Mr. T. Crook raises an important question concerning the probable method of transport of the boulders and shells which are now found at levels much higher than their probable points of origin. Although he quotes two passages from the writings of Sir Archibald Geikie and Professor Bonney pointing out that it is difficult to understand how the ice could ascend steep slopes

https://doi.org/10.1017/S0016756800110969 Published online by Cambridge University Press

to heights of more than a thousand feet, he suggests what seems far more difficult to grasp, i.e. that the lower layers of ice, owing to the formation of internal shear-planes, rose locally to the surface and carried with them portions of the ground moraine.

Being an advocate of the view that an ice-sheet may drag along with it portions of the floor over which it moves, especially if the floor be frozen, and carry such portions up slopes of more than a thousand feet, I do not resent the rendering Mr. Crook gives of such views; neither do I dispute the fact that, as he suggests, upward thrusts and contortions may be seen in glaciers. My experience, however, is that such signs of 'upward thrust', by which I understand him to mean shear, are confined to portions of the glacier where the surface is rapidly melting. In such places the ice is in compression and the glacier surface is rising to make up for the loss.

Thrust is credited with far too much importance as a cause of glacier flow. Rather should we attribute the flow to the absence of support in front. A glacier moves much as does a river. Where the slope is small the velocity of the ice or water is slow and the river or glacier deep; where the river or glacier is wide the flow is slow and

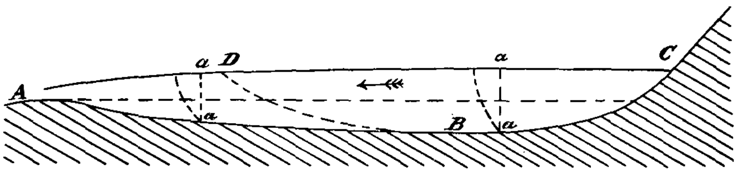

FIG. 1.

the ice or water shallow. Gravity is acting upon every portion of the mass, and the speed and thickness everywhere adjust themselves so as to pass the volume of ice or water to be got rid of. It has been suggested that the forces due to gravity acting on a glacier could not cause shear in its mass; for a similar mass of soft clay would not shear, and clay is much less capable of resisting shear than is ice. Clay, however, is not a viscous substance, and on a slope the material in front acts as a permanent buttress to prevent motion. With ice the front gives way, either by suffering longitudinal compression or by flow, and the rear portions follow.

When large glaciers are concerned the flow is quite regular; there may be shear where the stresses are sufficiently great, but such shear-planes are strictly related to the floor upon or against which the ice rests. Any local upthrust would soon raise a mound on the glacier surface, the weight of which would check further uprise. Many seem to experience difficulty in understanding how a glacier can move up a slope and drag rock masses along with it. Now the movement of a glacier is not necessarily due to the slope upon which it rests. The motion is due to the slope of the upper surface of the ice, which may be in the opposite direction to that of the floor upon which it rests.

We will suppose that the glacier rests in a hollow as in Fig. 1.

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Here the upper surface of the ice slopes from *C* towards *A*, and the flow is in the same direction. All the ice in the hollow is in equilibrium and is urged in the direction of the arrow by that portion which is above the lip *A* and extends towards *C*. Very little force indeed is therefore required to raise the ice from *B* to *A*. The ice will get thinner as it advances, and the slope of the upper surface at each point will assume the angle required to deliver the proper volume of ice at any cross section, *aa*, *aa*.

If the glacier floor were immovable and the ice were frozen to it the rate of motion at the bottom would be very small indeed if local shear did not take place. We have proof, however, that the glacier not only undergoes internal distortion, but that it frequently slips over the floor as well. In Spitzbergen, where the ground is frozen for hundreds of feet in depth, it is clear that ice flowing over such a floor would freeze to it and drag it along. Under these circumstances large masses of frozen gravel and sand would become incorporated in the lower portion of the glacier together with boulders, and these inclusions would be thawed out and redistributed when they came to their journey's end. The 'pushing' effect of the ice front against loose material as the glacier advances is no doubt considerable; but it is rather to the work effected by the debris-charged lower portion that the transport of material is due.

Mr. Crook suggests that the transport and lifting are more likely to be the result of upward shear in the ice, say along the dotted line *BD* in the figure, than along the floor from *B* to *A*. This seems very unlikely.

If the Rhone Valley were filled with ice up to about the level of the numerous hanging valleys the smaller glaciers from these valleys would flow on to and over the surface of the main Rhone Glacier, and subglacial moraine would thus find its way to the upper levels. I do not think it at all likely, however, that bottom moraine would find its way to the surface by upthrusts in the ice.

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Inglewood, Longcroft Avenue,
Harpenden, Herts.
March 13, 1911.

GEOLOGY OF PADSTOW AND CAMELFORD.

Sir,—In the notice of the Geological Survey Memoir on the Geology of Padstow and Camelford (p. 136) it was stated that the two new maps which accompany that memoir "show, for the first time, the divisions of Lower, Middle, and Upper Devonian". So far as the one-inch maps of the Geological Survey are concerned, this is quite correct. Nevertheless, mention should have been made of the fact that the main divisions of the Devonian rocks had been represented on a small map by Mr. W. A. E. Ussher (Trans. Roy. Cornwall Geol. Soc., 1891, p. 273). That map was constructed from lithological descriptions in De la Beche's Report, the data being interpreted by Mr. Ussher from his intimate knowledge of the Devonian rocks in South Devon. Although the relative position of the Meadfoot and Looe Beds and of the Dartmouth Slates was not then understood, the

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