The Editor,
The Journal of Glaciology

SIR,

Internal Moraines and Rock Glaciers *

On reading J. G. McCall's important study of a cirque glacier (*Journal of Glaciology*, Vol. 2, No. 12, 1952, p. 122), I think that what he calls "the sole," a debris-laden layer 30 cm. thick, is really the deep moraine. It seems well established that internal moraines are really debris-laden layers (Robert P. Sharp, *Journal of Glaciology*, Vol. 1, No. 4, 1948, p. 182).

Most of the glaciers in the Juncal group (Andes of Santiago), have debris-laden layers extending upwards from the bottom for over a quarter, a half, or even more of the thickness of the glacier. The study of the Juncal Sur Glacier shows that it is neither a layer of dead ice, nor a glacier on which another one is superimposed. This glacier advanced in 1949, flowing over four cliffs 600 m. high in total, and causing a jumble of seracs. The debris-laden ice appears on the higher cliff, on both sides of the system of seracs, and around the small "piedmont glacier" formed at the foot of the cliffs. On the higher cliff it constitutes one-third of the thickness of the glacier.

I should be very glad to know whether analogous phenomena have been observed in other countries. In the references which I have found (W. H. Ward, *Journal of Glaciology*, Vol. 2, No. 11, 1952, p. 11, for instance), the author spoke of clean and active ice slipping over dirty and dead ice. Was there no evidence that the two layers had moved together at some time?

I suppose that in this region, where glaciers have rarely completely laid bare a friable rock (porphyrite), the fragments become incorporated in the glacier ice over a considerable depth and flow with it. It is only in the alpine type of glacier, with a strong flow which has swept a hard bed bare, that this deep layer has almost disappeared.

In an overflow of the Olivares Beta Glacier to the west (Ventisquéro Colgante del Cerro Negro), now motionless, the debris-laden stratum extends downwards from the top, at an altitude of 4600 m. The clean layer has retreated from about 3400 m. to about 4100 m. during the past 30 years. In its place lies a glacier, wholly covered with detritus, coming from the melting of part of the deep moraine. From a distance this masked glacier resembles a typical "rock glacier," of which many are found in the area. Although in varying stages of development, they all seem to have the same origin.

The debris is disposed in corrugated planes, almost parallel to the ground, and seems to have been caught up from the ground. (In a wholly covered glacier, the Mono Verde West Rock Glacier, I was able to examine the earth, which filled a slip plane, in detail.) The fact that McCall did not discover any rock flour in the debris can be explained by Boyé's theory that corries are broken up in periglacial conditions. Rock flour comes next, from the rubbing of the debris-laden ice on the bed rock.

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6 *May* 1953

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* Professor R. F. Flint describes a rock glacier as follows:

In form it resembles a small valley glacier; its distal area is marked by transverse concentric ridges, and it heads in a cirque. It consists of ragged, angular nonsorted rock fragments, many of them very coarse, derived from the walls of the cirque. In some rock glaciers interstitial ice is present as a cement between the rock fragments.—*Ed.*

SIR,

The terms "Névé" and "Firn"

I see that in Mr. M. M. Miller's letter in the November 1952 issue of the *Journal*, page 150, the definition of firn suggested by the Committee on Snow Classification of the International Association of Scientific Hydrology is as follows:

> "old snow which has outlasted one summer at least (transformed into a dense heavy material as a result of frequent melting and freezing)."

If the words in brackets are to be considered part of the definition this will be a mistake. It may be true that in the Alps and most mountain regions firn is formed from snow in this way, but the greater part of the firn of the world, i.e. in the interior of polar ice caps, has never been subject to melting and freezing but is transformed "into a dense heavy material" by pressure and recrystallization only. It seems to me, therefore, that the suggested definition will lead to confusion. I would either omit the

words in brackets altogether, or say "old snow which has outlasted one summer at least and is transformed into a dense material." Polar, as indeed all, firn is characterized by the fact that (*a*) the particles are to some extent cemented together, but that (*b*) the air interstices still communicate with each other. (*a*) distinguishes it from snow, (*b*) from ice.

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12 *December* 1952

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SIR, *"Processes of ice deformation within glaciers" by the late Max Harrison Demorest*

In reference to the last paragraph of the very interesting comments by Mr. J. W. Glen, of the Cavendish Laboratory, on the paper by the late Max Harrison Demorest (*Journal of Glaciology*, Vol. 2, No. 13, 1953, p. 219 and 201–3 respectively), the recrystallization induced by deformation in Demorest's experiments was, in reality, so rapid as to be practically *instantaneous*. In fact, it was so rapid that the process is recorded in moving pictures that were taken by Dr. Demorest during the course of an experiment. The recrystallization could be observed to have taken place as a sudden change during the passage of a few frames, at minute intervals, of the moving picture film.

Since recrystallization in metals proceeds with variable speed at different temperatures, it may be that the instantaneous recrystallization in ice is caused by the fact that Demorest's experiments were carried on at temperatures that were relatively near the melting point of ice.

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REVIEWS

SIR DOUGLAS MAWSON ANNIVERSARY VOLUME. Contributions to Geology in honour of Professor Sir Douglas Mawson's 70th Birthday Anniversary, presented by colleagues, friends and pupils. *Eds.* M. F. Glaessner *and* E. A. Rudd. University of Adelaide, 1952. ix+224 pages.

SIR DOUGLAS MAWSON, who is so well known to glaciologists for his work in the Antarctic—member of Shackleton's Expedition 1907–08, leader of the Australian Expedition 1911–14 and of the British, Australian and New Zealand Expedition 1929–31—was born at Bradford, Yorkshire, in May 1882. Since 1905 he has been lecturer and professor in geology in the University of Adelaide, and in honour of his 70th birthday anniversary his colleagues, friends and pupils have presented him with this volume of contributions to geology. All members of the British Glaciological Society will wish to be associated with their Australian colleagues in paying honour to their fellow member.

The book consists of sixteen articles, all but one of which deal with geological subjects. It is the exception which is of particular interest to glaciologists, for it is an article on "Pleistocene glaciation in the Kosciusko region," by W. R. Browne. The Kosciusko plateau, in the south of New South Wales, is the only region in Australia known to contain traces of extensive glaciation. There can now be little doubt that this glaciation is of Pleistocene age, and therefore may be expected to throw some light on the extent and development of the Pleistocene Ice Age in the southern hemisphere. Considering the importance of the questions involved it is surprising how little it has been studied. Glacial features were first reported from the Kosciusko area in 1851, but it was not until fifty years later that the first detailed account was given by Professor David in 1901. Nearly another fifty years passed before further extensive work was undertaken, in 1946 and 1951, by a Joint Scientific Advisory Committee of several Australian scientific societies and