

a pro-talus rampart in Snowdonia, North Wales. On the concentric ridges of the moraine damming Llyn du'r Arddu, a small tarn north-west of the main Snowdon Ridge, they noted that on most of the moraine ridges

"rest *sub-angular* perched blocks, whilst the innermost crescent of the drift dam consists of *angular* blocks, as though some at least of this material was rather of the nature of snow-slope detritus than true moraine".

Even more explicit is a remarkable account of recent pro-talus rampart development on the north face of Ben Nevis, the highest mountain in Scotland, where Gatty (1906, p. 491) observed in Coire na Ciste

"a little tarn ... enclosed by a semi-circular embankment rising some 6 or 8 feet above the water level. This dam is built up stones of all sizes, from pebbles to blocks 4 feet across. Some of these had plainly fallen last spring ... . The way in which the dam is forming is this: in the spring a tongue of snow projects over the site of the tarn, and terminates against the dam; blocks wedged off the cliffs by the winter's frost roll or slide down and come to rest at the foot of the snow-shoot, and so build up the dam".

Gatty's account also included two photographs of this feature, and he went on to note that

"Several instances of old semicircular embankments of identical formation are to be found amongst the hills of the English Lake District; these almost certainly all date back to glacial times".

He also mentioned another recent example in the Alps (p. 492). The above examples reveal that Daly's (1912) account of pro-talus ramparts was by no means the first to appear, though it may well represent the first documentation of North American examples.

Secondly, it seems debatable as to whether Daly's term "winter-talus ridge" is more appropriate than "pro-talus rampart". Not only has the latter term become firmly entrenched in the literature on the topic, but also it seems more accurate, on three counts. First, recent work on actively accumulating ramparts in northern Norway (Ballantyne, in press) has shown that rampart accumulation takes place in summer rather than winter, as these ramparts are entirely covered by snow in winter so that debris from the cliffs up-slope overshoots the rampart crests. In such circumstances, the term "winter-talus ridge" seems inappropriate. Secondly, "rampart" is in some circumstances at least more accurate than "ridge", as some examples do not possess a proximal slope (e.g. Ballantyne and Kirkbride, 1986, p. 662). Finally, all examples known to the author or documented in the literature lie at or near the foot of a talus slope, which suggests that "pro-talus" is an apt descriptor; that illustrated by Daly (1912, pl. 57) is a fine example of this.

Finally, recent studies of actively accumulating pro-talus ramparts suggest that traditional definitions of such features require revision. Butler (1986) adopted the genetic definition:

"A 'pro-talus rampart' is a ridge or ramp of debris that forms where clasts fall from a cliff face, slide, or roll across the surface of a perennial snow bank of somewhat standard dimensions, and accumulate at its base".

Similar definitions have been proposed by several authors in the past, including the present writer (Ballantyne, 1986; Ballantyne and Kirkbride, 1986). As noted by Johnson (1983), however, the validity of this mode of accumulation tends to have been assumed rather than demonstrated, as most accounts of pro-talus ramparts concern relict (usually late Pleistocene) examples. Recent work on actively accumulating ramparts in Japan and Norway indicates that other processes such as debris flow (Ono and Watanabe, 1986), reworking of till deposits from up-slope (Harris, 1986), and slush avalanches (Ballantyne, in press) also contribute substantially to the accumulation of at least some

ramparts, and account for the presence of abundant fines within these ramparts. A more general definition seems to be required, such as:

"a ridge or ramp of predominantly coarse detritus, usually located at or near the foot of a talus slope, that formed through the accumulation of debris along the down-slope margins of a snow bed".

Whether *perennial* snow or firn is necessarily involved seems uncertain, though Gatty's (1906) account seems to suggest that some examples may have formed in association with seasonal snow beds. Further research is necessary to clarify this point.

I am grateful to D. Unwin of the University of Leicester for drawing my attention to the early accounts of pro-talus ramparts by Ward (1873) and Marr and Adie (1898).

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SIR,

### *Early description of pro-talus ramparts*

Butler (1986) rightly pointed out that Daly (1912), early in the present century, drew attention to the distinctive alpine land form that Bryan (1934) subsequently named "*pro-talus rampart*". However, Daly was not the first to describe and discuss the origin of these features. Cross and Howe (1905, p. 25) described pro-talus ramparts in the San Juan Mountains of Colorado which were forming at the front of snow banks, mainly at the base of north-facing cliffs, and referred to them as "snowbank accumulations". In

their words, the "snowbanks would form highways down which rocks loosened by frost would travel from the cliffs to the floors of the amphitheatres, and the effect would be to deposit waste at a greater distance from the cliffs than ordinary talus, and to protect a zone at the very foot of the cliffs from excessive talus accumulations." Howe (1909, p. 35-36, fig. 3) subsequently described them in more detail and illustrated their inferred origin by a diagram that is both clearer and more informative than the one which Daly (1912, fig. 41) later published. In this report, they were referred to as "snowbank deposits". Although Daly referenced several U.S. Geological Survey publications in his memoir, he did not cite Howe's observations; apparently that work was unavailable to him at the time of his writing. The Cross and Howe folio was published 7 years before Daly's report appeared, but he may not have seen the brief description it contained.

In addition to Cross and Howe's description of pro-talus ramparts, I have come across an even earlier discussion of these land forms in a paper that apparently escaped the attention of geologists working in the American west during the early years of this century. In describing the varied surficial deposits of the upper Indus River basin in the regions of Gilgit, Baltistan, and Ladakh, Drew (1873, p. 445) described different forms of talus along the valley walls and provided a description of what is clearly a pro-talus rampart:

"sometimes it happens that a talus of snow forms first, in much such position and form as the stone-heap itself might acquire; and then upon this snow-heap rolls down the loosened stuff, which therefore finds rest only at the foot, round the edge, of the snow-talus; the melting of this in summer leaves a heap of stones which may be of considerable height, though it is not very likely to increase by additions in successive seasons. Such circumstances as these should be borne in mind when one meets with isolated heaps, not far from the mountain-side, which might otherwise be taken for moraine-heaps ... the heap at the foot of the snow talus is not unlikely to take the form of part of a ring abutting at its ends against the mountain, and thus enclosing a hollow ...".

This description, which antedates Daly's by more than a third of a century, may constitute the earliest mention of these alpine land forms by a geologist.

Butler (1986) argued that Daly's term "winter-talus ridge" takes precedence over the term "protalus rampart" later introduced by Bryan. One could argue equally well that Cross and Howe's term "snowbank accumulation" (or Howe's subsequent "snowbank deposit") should take precedence over Daly's term. However, I find neither of these terms very satisfactory, for they are imprecise and ambiguous. Daly's term can also be faulted, for it implies that the talus ridge forms in winter. Although this may be true in some cases, I know of no definitive studies showing that sliderock production and accumulation at the toe of a snow bank occurs exclusively, or even predominantly, during the winter season. Some studies have shown that release of rock debris from mountain slopes reaches maximum frequency during mid- to late spring (May-June) when rapid thawing of frost-riven cliff faces takes place (Rapp, 1960); in polar latitudes, such activity may peak during the summer (e.g. Åkerman, 1984). Rock debris generated during the height of the accumulation season tends to become buried within the growing snow bank and would be unlikely to slide or roll down the unconsolidated snow surface to its toe. Bryan's term "protalus rampart" avoids these problems, for it is a descriptive, non-genetic designation. Until more is learned about how and when these land forms develop under different geographic conditions, the widely used term proposed by Bryan remains a viable and preferred one.

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SIR,

Concerning early descriptions of pro-talus ramparts

I should like to thank S.C. Porter (1987) and C.K. Ballantyne (1987) for their interesting letters concerning pro-talus ramparts, written in response to my previous comments (Butler, 1986). They make several points in their letters, and I should like to comment on some of these issues.

First, it was certainly not my intention to ignore or denigrate the contributions of geologists and geographers working in the British Isles, cited by Ballantyne (1987). I did not allude to those works because they do not describe pro-talus ramparts. Ballantyne cites three papers which he interprets as providing earlier written descriptions of pro-talus ramparts than that of Daly (1912). Ward (1873, p. 426) indeed did hypothesize a type of "moraine-like mound", based on a suggestion from "Mr. Drew, late from Cashmere", but did not actually provide any field description of such a feature in the Lake District. Furthermore, Ward's descriptive mounds (note that he did not use the term ridge or rampart) could easily be interpreted as attributable to snow-avalanche impact (Corner, 1980). Ward's brief comment cannot be construed as describing a pro-talus rampart.

The comments of Marr and Adie (1898) are also sufficiently vague as to preclude the establishment of primacy. Their statement that the angular blocks resting upon the sub-angular blocks of a moraine were "rather of the nature of snow-slope detritus" may again refer to avalanche-deposited materials. It is also clear that the feature in question was a moraine, which had undergone minor post-glacial modification.

The description of Gatty (1906) is, as Ballantyne states, "a remarkable account". It is, however, a remarkable account of glacial moraines, not pro-talus ramparts. Both of Gatty's (1906, p. 490, 491) photographs refer to the land forms in question as *morainic dams* (an item omitted in Ballantyne's letter). A reading of Gatty's description, as well as interpretations of the photographs, reveals that the ridges in question are weathered, stable glacial moraines. A veneer of some isolated, recently deposited clasts on the surface of a moraine does not make the moraine a pro-talus rampart.

The papers cited by Porter (1987) certainly do describe features later called pro-talus ramparts, and I thank him for calling them to my attention. I should be pleased to hear of other early descriptions of these land forms, and hope to hear from readers of the *Journal*.