

## GLACIER BANDS

## CONFERENCE ON TERMINOLOGY

The following report was circulated to a limited number of glaciologists by Mr. W. H. Ward during the summer of 1952, with a request for their comments.

It is followed by a synopsis of the suggestions and criticisms received by Mr. Ward to date and it is hoped that this will encourage further written discussion for publication. Further comments and suggestions should be sent to the Editor. A second Conference will be held in the autumn which, it is hoped, will be able to agree on a definite recommendation for banding terminology. Members and others wishing to attend this conference should send their names to the Secretary so that they may be advised when it will take place.

## MEETING HELD AT THE DEPARTMENT OF GEOGRAPHY, CAMBRIDGE, ON 1 MAY, 1952

PRESENT: Mr. G. Seligman (In the Chair), Mr. B. Battle, Miss J. Clark, Professor F. Debenham, Mr. J. Glen, Professor S. E. Hollingworth, Mr. H. Lister, Mr. J. McCall, Mr. M. Miller and Mr. W. H. Ward.

The purpose of the conference was twofold: (a) To establish some reasonable terminology for glacier banding so as to encourage glaciologists to be more explicit and to avoid the misunderstandings which have occurred in the past, especially in the literature. For example, the term "blue band" was often used without further qualification, whereas it was recognized that blue bands had various origins and it was essential to know what kind of blue band was being considered; (b) To prepare the way for continuing research on the formation of the various bands.

Mr. G. Seligman had prepared a tentative classification on a generic basis, but this suggestion was thought to be premature, since the genesis of some bands of quite characteristic form was not necessarily well established. The meeting therefore proceeded to classify bands according to their morphological aspects, thus following the present trend of terminology but with additional descriptive qualifying words.

It was agreed that the term "band" meant a zone or layer of extensive laminar, or of more limited lenticular, form that was relatively different in appearance to the adjacent material. The band may consist of ice, firn, snow, rock, debris, organic matter and any mixture of these materials.

The conference dealt, first, with bands generally seen and described in limited exposures in vertical sections (in crevasses, melt water channels, pits and tunnels) and which may have outcrops on the glacier surface. And, secondly, with bands generally seen and described in relation to their appearance as outcrops on the surface of a glacier (generally in the ablation zone).

## I. BLUE BANDS (laminar or lenticular bands of relatively bubble-free ice)

(a) *Stratification blue bands*. Formed in the firn roughly parallel to the surface from either, (i) melt water seeping downwards through the firn and refreezing, or (ii) crusts formed at the surface and subsequently buried under fresh snow. The term "stratification" was not entirely acceptable; the term "sedimentary" was rejected. (It may be necessary to distinguish (i) and (ii). W.H.W.)

(b) *Infilled blue bands*. Formed from extraneous water freezing in cracks or crevasses. The crystals grow normal to the walls of the crevasse and usually take the form of "candle ice." These bands are commonly formed in a roughly vertical direction. ("Infilled" was suggested for want of a better word, "Infiltrated" is another suggestion. W.H.W., G.S.)

(c) *Tectonic (deformation, dynamic?) blue bands*. Generally formed in dense or fairly dense ice as a result of fracture, dislocation or shear, and giving rise to a change in crystal structure with

local reduction in the total volume of air bubbles (do the number of bubbles decrease or does their size decrease?). Subglacial rock or organic debris may be entrained by shearing, and in this case the bands would be called "debris-laden shear bands or planes."

Tectonic blue bands may occur from a single dislocation and would be called (i) single, or from a series of separate dislocations close together and roughly parallel, giving rise to a broader (ii) multiple or composite band.

## II. DIRT BANDS

Dirt bands are formed as stratification bands in the accumulation area. The dirt consists of organic or inorganic of aerial origin, such as lichen, volcanic dust or rock debris falling through the air from the mountain side on to or into the firm. This is in contrast to "debris" which refers to subglacial material picked up by glacier ice (see above). (In view of the formation of bands as a result of crevasses becoming entirely filled with dirt, especially in volcanic areas, there seems to be a need for an "infilled dirt band". W.H.W.)

## III. OGIVES

It was agreed that the word "ogives" is descriptive of the form of a series of bands of various origins seen on the surface of a glacier and resembling the architectural form, *i.e.* like the ribs of the Gothic vault. There was a good case for retaining this word because of the similar spellings in French and German. It was further agreed that any band of material whatever its substance or origin and which at some early stage extended right through the cross-section of a glacier would be drawn out by deformation to form a single ogive. Ogives may form, at some stage, the surface pattern of almost all the bands previously mentioned.

(a) *Dirt band ogives* (not "Alaskan," since they are neither peculiar to Alaska and apparently not even the most common form of ogive there).

(b) *Forbes's ogives* (including the fine structure of similar shape between the ogives). These bands are very common below ice falls and below valley convergences. (These ogives are characterized by undulations or waves on the glacier surface with a wave length corresponding with the spacing of the bands and thought to correspond with notable variations in the rate of flow. The outcrop of the bands and that of their fine structure are often sprinkled with recent airborne dirt, which accentuates the banded appearance. But the banded structure appears to be fundamentally associated with variable ice density, crystal structure and orientation. W.H.W.) It was thought desirable to find another name for these bands, since although Forbes gave a coherent description of them, he also described other bands, and other writers had described them earlier. (Tectonic ogives, G.S.; Wave ogives. W.H.W.)

(c) *Shear plane ogives*.

(d) *Debris-laden shear plane ogives*.

## IV. LONGITUDINAL BANDS

Parallel bands, like plough furrows, in the direction of flow, right across the glacier surface and extending vertically into the glacier to at least the depth of open crevasses. Occur where a glacier narrows; of tectonic origin and probably due to differential flow between side and centre.

## COMMENTS

Professor R. HAEFELI, ZÜRICH

"Fundamentally these proposals appear to be valuable and I should be grateful if they could be discussed, after further clarification, with the Swiss Glacier Commission. I was particularly interested in the remarks under Section III (b) (Ogives). The question now arises whether

Forbes's ogives in the form of pressure waves could not appear simultaneously at the glacier surface as 'dirt band ogives.' According to our observations at the Mt. Collon Glacier (*Journal of Glaciology*, Vol. 1, No. 9, 1951, p. 498) this would be a possibility."

Professor R. P. SHARP, PASADENA, provides comments which he says are "very hastily framed." They are condensed below :

#### *Section I*

(i) Why follow the old terminology by using 'band' when actually we are describing a three-dimensional *layer*? A band is a thin, flat, flexible strip.

(ii) Why emphasize the (a), (b) and (c) subdivisions of Section I, blue *layers*, when the intervening bubbly layers are just as numerous and important?

(iii) I suggest using the geological terminology, such as 'sedimentary blue layers' with two sub-types (a) sedimentary dirty layers. (b) sedimentary ice (or blue ice) layers.

(iv) The term 'infilled blue bands' seems particularly inappropriate. Suggest 'ice veins,' since their mode of formation is not unlike that of geological veins.

(v) Tectonic layers could be called 'foliation,' in the same way that layering in rocks which have flowed is described.

#### *Section II*

The dirt bands could be included more properly under sedimentary banding with sedimentary dirty layers.

#### *Section III*

'Ogives' is a good term, but the wide application assigned to it is surprising as it seems to overlap very badly the concept of foliation mentioned above. Suggest ogives should be limited to types of dirty ice layering such as described in sub-headings (a) and (b).

#### *Section IV*

This section seems unnecessary if we can recognize that foliation may be longitudinal as well as transverse.

In addition, it is suggested that some recognition should be given to the definite shear zones or shear layers without debris, particularly those layers in which the ice is not re-crystallized but appears as a loose granular substance, which are so common in some glaciers.

Mr. JOEL E. FISHER, NEW YORK

#### *Section III*

"Ogives is so generally accepted and so expressive, I hope all will stand behind its formal acceptance."

#### *Section III (a)*

"Dirt band, applied to ogives, is a description formerly applied to both the majestic Forbes's type of ogives and to those smaller ogives to which I had rather hastily applied the adjective 'Alaskan.'"

Mr. Fisher further suggests that it is perhaps equally unhappy to transfer the word "dirt band," a title formerly applied indiscriminately and ignorantly to both types of ogives, to just one of the two leading types of ogives. He suggests instead the term "Arctic" or "laminar type" ogives. "Arctic" because they are proportionately far more common in high latitudes.

Professor F. DEBENHAM, CAMBRIDGE

#### *Section III*

"I am not sure I like the word *ogives* to describe a pattern which is more or less a horizontal one."

Mr. J. W. GLEN, CAMBRIDGE

*Section II*

"Dirt bands are so defined as specifically to exclude debris picked up from the bed; is this desirable? A separate sub-class could be made to cover such bands, though it should be borne in mind that it may not always be possible to tell whether the dirt is 'debris' or some other form." The definition should make clear whether the term includes the ice between two adjacent layers of dirt.

*Section III (b)*

The term Forbes's ogives appears to cover both (i) the large-scale phenomenon conspicuously displayed on the surface and (ii) the fine laminar structure which is seen in crevasses. It might be desirable to distinguish between these and call (i) annual ogives, or wave ogives, or just Forbes's ogives (*i.e.* the waves below an ice fall and the bands lower down consisting of dirt collected in such waves) and call (ii) fine bands (or ogives) or bubbly bands (or ogives), (*i.e.* the fine structure that *alone* appears to be visible throughout the depth of a glacier).

*Section III (c) and (d)*

"The terms 'shear plane ogives' and 'debris-laden shear plane ogives' seem to contradict the decision to make the classification morphological. It is not clear what bands they are intended to cover and it is doubted whether they are good terms for anything."

Mr. W. H. WARD, WATFORD

"I disagree with many of the details in the notes of the Conference that Mr. G. Seligman and I prepared. I did not wish to impose my own ideas, except in so far as it seemed necessary to add a few comments and explanations for clarity and to suggest omissions; for the same reason I refrain from making detailed comments here. In condensing, for the sake of brevity, the valuable comments received so far, I trust that there has been no misrepresentation.

"I have omitted most of the favourable comments received. Those who did not attend the Conference may not have realized how discursive and animated it was.

"The Conference decided that a generic classification was premature, but in the light of the above comments, especially those of Professor Sharp and Mr. J. Glen, it seems evident that a skeleton generic basis is necessary to form a framework for even a provisional morphological classification, somewhat on the lines of the Chairman's original proposal. The following brief statement is probably a sufficient framework.

"The layers in a glacier consist of three materials, (i) ice, (ii) bubbles, (iii) dirt or debris. They can be placed in position and arranged relative to each other by one or more of the following processes, (a) sedimentation, (b) plastic flow, foliation or tectonic movement, (c) material falling or rising into local cracks and holes. The numerous combinations of (i), (ii), (iii) and (a), (b) and (c) include in a broad way the genesis of all visible features in a glacier.

"If the above statement, irrespective of terminology, is acceptable, it should be possible to assemble our morphological descriptions around it. Presumably if this is done, there will be left over a number of morphological features whose formation is in dispute. These could be relegated to a list, accompanied by any controversial statements.

"The articles in this journal show that we know sufficient about glacier physics, at present, for authors to be inventing names on a generic basis, because some of the features are not simply described morphologically. This is surely a sign of progress and our classification should allow for it.

"As to terms, I believe it will be necessary to discard several of the traditional ones to avoid further confusion with erroneous conceptions."