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SO CALLED „VALLONS DE GELIVATION" IN CENTRAL LABRADOR-UNGAVA**

INTRODUCTION

The establishment in 1954 of a permanent sub-arctic research laboratory in central Labrador-Ungava under the direction of McGill University has subsequently led to a considerable increase in scientific data from this hitherto, rather remote area. A considerable proportion of the resulting publications have been in the field of geomorphology. Increasing attention is being paid to a series of long-termed and detailed examinations of periglacial processes within the area, including a detailed study of permafrost (Ives 1960, 1961; Williams 1961; Haywood ed. by Andrews & Matthew 1961).

A number of papers have dealt with periglacial, or suggested periglacial forms (Twidale 1956, 1958; Derruau 1956; Henderson 1956). In a recent publication of the *Biuletyn Peryglacjalny* Dorywalski (1960) reviewed Twidale's 1958 paper on „Vallons de Gélivation dans le centre du Labrador", and also commented on the 1956 publication dealing with the same topic. Dorywalski commented on the somewhat similar forms that have been described elsewhere in the literature, notably in Greenland and in Japan, and he stated that their genetic relationship „cannot escape recognition".

It is the purpose of this paper to present an alternative theory to that originally proposed by Twidale, a theory that is more in accord with observational data and with theoretical considerations (Andrews 1961 a). This alternative explanation is not intended to apply to the other areas mentioned by Dorywalski, but certain of the conclusions do require at least consideration before a periglacial origin for these other forms is fully accepted.

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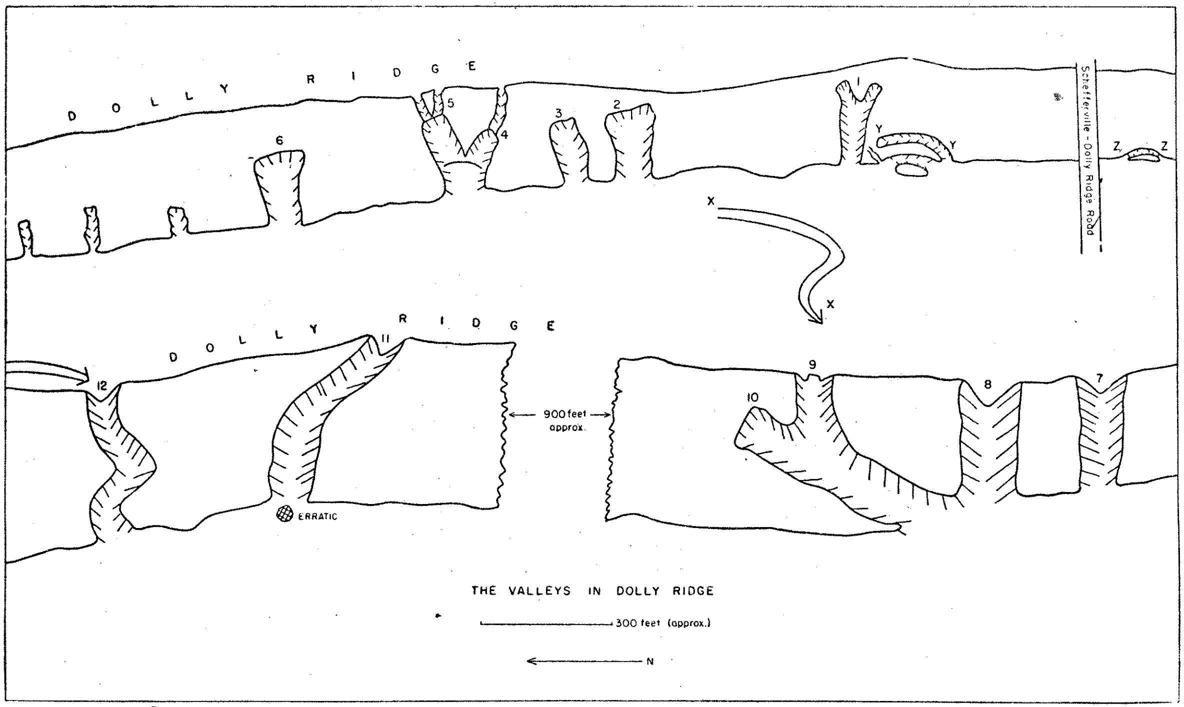

Fig. 1. A sketch of the varying morphology of the valleys incised into Dolly Ridge. Taken from a plane table survey

ORIGINAL DESCRIPTION OF THE „VALLONS"

Twidale described the vallons as alcove-like valleys (fig. 1) incised into the west face of Dolly Ridge, a structural ridge of argillites some 3 miles east of Schefferville. Up-valley the valleys end in a vertical rock wall, while down-valley they open out onto a shale vale, with pro-talus moraines across the mouths of the valleys. It was postulated that the valleys were post-Pleistocene features, caused by frost-action widening major joint lines. The resultant frost-shattered debris was then removed by solifluction.

The valleys were re-examined during the summer and autumn of 1959, and in the spring and early summer of 1960 when the author was a staff member of the McGill Sub-Arctic Research Laboratory at Schefferville. It was soon apparent that major criticisms could be levelled at the earlier description of the valleys, as well as their interpretated origin.

MORPHOLOGY OF THE VALLEYS

A total of 12 valleys were delimited on the west face of Dolly Ridge (Twidale 1956; Andrews 1961 a), and these were re-examined and mapped by a plane table survey. This survey revealed a striking diversity of valley forms, though the original description only emphasized the alcove-like form, and variations upon this form were not fully considered. However, it is the extreme variation from this simple form that strongly suggests that the periglacial origin is unsound, and cannot possibly explain the observed morphological variations from valley to valley. Figure 1 illustrates the morphology of the valleys. It is apparent that only 6 out of the 12 valleys correspond to the alcove-like form (fig. 1, valleys 1, 2, 3, 4, 5, 6, and pl. 1) and even then there are important modifications. Five of the valleys, numbers 7, 8, 9, 11 and 12 on figure 1, completely breach the escarpment crest, and open out onto the shale vale (pl. 2).

The majority of the valleys have a straight linear form, but again this description is not wholly accurate, for valleys 9, 10, 11, and 12 are markedly curved and transcordant with structure (pl. 3). Valley 12 has in fact a noticeable meander curve. When the sequence of morphological changes is considered then there is an obvious northwards increase in the magnitude of escarpment breaching, and in the disregard of structural control.

There is strong observational evidence to suggest an association of the valleys with glacio-fluvial forms. At Y—Y, and Z—Z (fig. 1) are there glacial drainage channels of the in-and-out variety, which bear adequate testimony to the efficiency of glacial meltwaters as an agent of erosion.

Further north, and west of valleys 1 and 2, a very distinct valley trends parallel to Dolly Ridge, before it turns at right angles, cuts through a secondary ridge, and then turns south along the main valley floor. The valley resembles in form and behaviour, subglacial drainage as described by Ives (1959) and Derbyshire (1959). The association of valley and glacial drainage channel occurs once again at the head of valley 12, where a glacial drainage channel leads directly into the valley, and must have carried meltwater to it.

Finally, at the outlet of valley 11 a massive erratic block was discovered. The surrounding slopes were negligible, and the boulder must, therefore, post-date the formation of the valley. The only means of emplacement is by deposition from a former ice cover, after the valley had attained its present form.

CRITICISM OF THE PERIGLACIAL HYPOTHESIS OF VALLEY FORMATION

Twidale considered that the valleys were the product of two processes: frost-shattering, and the removal of this material by solifluction. Certain experimental, observational, and theoretical considerations cast doubt on this mechanism of valley formation.

A number of detailed temperature measurements were taken in the spring of 1960, with the view to ascertaining the actual range and speed of temperature fluctuations beneath the rock/snow interface. The results showed that the temperature beneath the snowbank, and adjacent to the valley wall, only varied $\pm 1\,°C$ above and below the freezing point, though the air temperature varied from a high of 18 °C to a low of $-10\,°C$. Grawe (1936) and Reiche (1950) concluded that the potency of frost-shattering has been overemphasized. If it is to be an effective process, then the range of temperature change has to be considerable, and the speed of the temperature fluctuation has to be rapid; this situation cannot possibly occur under a snowbank, and the only possible location of an area of intense frost action would be the immediate margins of the snowbank. No evidence of present-day frost-action was noticed in these situations, and generally the valley sides were well covered with crustaceous lichens, denoting little action at least for some decades. Cook and Raiche (1962 a) have observed the development of active simple transverse nivation hollows in the Resolute area, Northwest Territories, where the margins of the nivation hollows show every indication of being enlarged by congelifraction and comminution; but at the same time both writers in another paper (Cook & Raiche 1962 b) stress that the data from Resolute indicates that there are „no cycles, apart from the annual cycle, at depths below a few centimetres". It is suggested that mechanical weathering in the Canadian sub-arctic, and even in the arctic is a slow process, except under certain favourable conditions. It is stressed that oft-quoted effects of frost-action are rarely proved by adequate quantitative work.

The suggestions that solifluction removed the coarse frost-shattered debris from the valleys is difficult to substantiate by direct observation, and theoretically it would seem impossible that solifluction could remove material of this nature unless it incorporated or overlaid finer particles of the silt/clay fraction. Another possibility that was considered by the present writer was that the material was removed by rock streams located within each valley, but a comparison of the nature of the apron of rock debris located in front of the valleys and the description of rock streams by Capp (1910) and Kesselli (1941) indicated that this explanation was not applicable.

ORIGIN OF THE VALLEYS

It is evident that in central Labrador-Ungava the slow process of frost-shattering is operative. Pls. 1, 2, and 3 all show well developed scree slopes, but it is important to note that the screes are generally well covered with crustaceous lichens, as are the vertical backwalls, denoting a deficiency in the supply of scree material (Andrews 1961 b).

It is suggested that the valleys are not post-Pleistocene forms, but are at least pre-last glacial in age (Wisconsin or its equivalent). It is postulated that the valleys were initially located along major joint lines which were slowly widened by the weathering process. It is not known to what extent the valleys developed during this period of initial growth, but at present, small incipient valleys are choked with debris, which would suggest that this early development would be similarly restricted. The available evidence, however, does indicate that the valleys were modified to their present forms during the final stages of the deglacierization of the Schefferville area, some 7 000 years ago. Ives (1959) and Derbyshire (1959) showed that the movement of glacial meltwaters was to the south in the area, and Ives concluded that the glacial meltwaters were penetrating the decaying ice mass, and that consequently the drainage channels were sub-glacial in origin.

In discussing the origin of the valleys there are three main points that have to be reconciled: one is the association of the valleys with glacial drainage channels; the second is the southwards increase in the degree of structural control and the third is the southwards decrease in the extent of the escarpment breach. It is considered that these characteristics of the valleys are related to their origin, and as such, are mutually interdependent. It is proposed that glacial meltwaters flowing sub-glacially along the vale east of the escarpment crest were diverted through a number of incipient „vallons de gélivation". The vale west of the Dolly Ridge escarpment is some 250′ below the vale to the east, and meltwaters flowing through the valleys would thus have considerable velocity and erosive power. This latter aspect is proven by the coarse outwash fans spread out in front of each valley. The degree of escarpment breaching, which decreases towards the south, was a natural outcome of the progressive reduction of velocity and volume of the meltwaters as they were led away through the structurally controlled sub-glacial chutes. The validity of this hypothesis is strengthened by the similarity between the Dolly Ridge system, and a series of sub-glacial drainage channels described by Derbyshire (1959) from an area 3 miles north of Schefferville.

CONCLUSIONS

The alternative theory of the formation of the valleys incised into Dolly Ridge stresses the complexity of their forms, and also the complexity of their origin. The valleys are at least pre-last glacial in initiation, but have been severely modified by meltwater during the closing stages of the deglacierization of the area. Post-glacial action has been restricted to the formation of scree slopes, which are now in a retarded state of development, and the widening of some major joint lines.

It is suggested that the postulated periglacial origin of the valleys, and the ready acceptance of this explanation is indicative of a tendency among some geomorphologists to attribute a greater degree of importance to the periglacial processes than is actually warranted. This tendency is to be deplored if it is based on theories lacking detailed observational and quantitative research.

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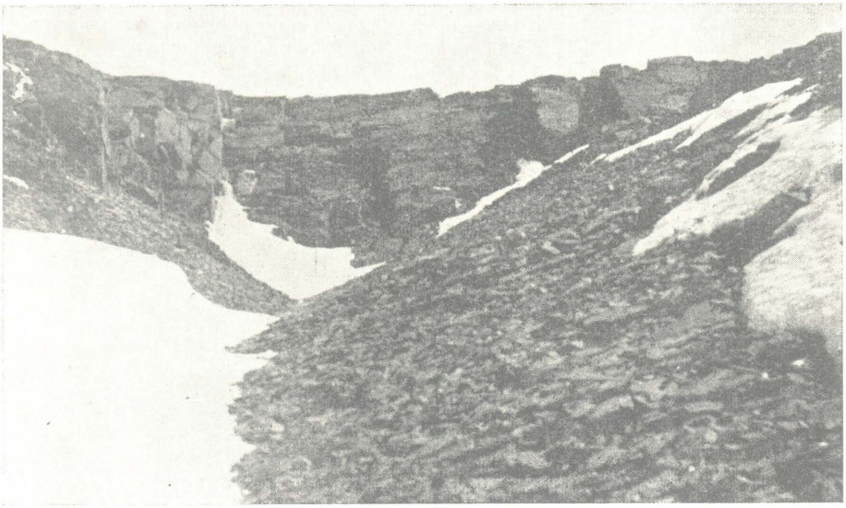

Photo by W. Mattox

Pl. 1. Classical „vallon de gélivation" as described by Twidale
Note the vertical backwall, and scree slopes. This is valley 2

Photo by W. Mattox

Pl. 2. This is valley 7. It breaches the escarpment crest and opens out onto the shale vale. Figure for scale

Photo by P. J. Williams

Pl. 3. Valley 11 as seen from near its intake. Note the curved nature of the valley which cuts across the structure