CLASTS WITH STOSS-LEE FORM IN LODGEMENT TILLS: A DISCUSSION

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Abstract: Clasts modified by glacial erosion are described from lodgement tills in front of the glacier Myrdalsjökull, south Iceland. Many clasts show modification of their lower surfaces in the same way as their upper surfaces. However, the lower surfaces have a smoothed down-glacier face and a truncated up-glacier face, which is the opposite orientation to that of the upper surfaces. This so-called double stoss-lee form is interpreted as a response to basal transport over abraded materials, following deposition of the clast and succeeded by glacial erosion. It is suggested that clasts with a double stoss-lee form are a diagnostic criterion for subglacial deposition by lodgement. Furthermore, the distribution and orientation of clasts with a stoss-lee form was investigated on a ground-moraine surface. 17.3% of 2199 clasts with an a-axis diameter > 30 cm had a stoss-lee form. The proportion of clasts with their smoothed ends facing up-glacier within ± 22.5° of the ice-flow direction was 72.7%. Thus, the preferred stoss-side orientation is closely related to the ice movement and indicates the direction from which the ice came. Only 11.7% of boulders with a divergent stoss-side orientation are located in connection with annual moraines. It is suggested that such boulders may have been re-deposited beneath the ice and not at the ice front by minor advances of the glacier.

INTRODUCTION

Many clasts embedded in ground moraine in front of present-day glaciers occur in a characteristic position with a smoothed, often bullet-nosed, up-glacier termination and an abruptly truncated down-glacier termination (Fig. 1). It is suggested that this stoss-lee form is due to subglacial erosion after lodgement of the boulder, and that the smoothed stoss-side orientation indicates the direction from which the ice came (Okko, 1955; Boulton, 1978; Krüger, 1979). Recently, Sharp (1982) demonstrated how size and lithology of clasts may influence the extent to which the above erosional modification occurs. However, Sharp (1982, p. 478) pointed out that in his study area (the forefield of the glacier Skálafellssjökull, south-east Iceland) the lower surfaces of boulders had not been smoothed and streamlined in the same way as their upper surfaces. Furthermore, he mentioned (p. 480) that clasts with a stoss-lee form, but with a divergent orientation relative to the ice-flow direction, had probably been re-deposited by minor advances of the ice front responsible for constructing small push moraines.

This note directs attention to (1) modification of the lower surfaces of clasts in the same way as their upper surfaces, and (2) discusses the orientation of clasts with a stoss-lee form.

The study site is the ground moraine in front of the northern margin of the glacier Myrdalsjökull, south Iceland (Fig. 1). The surface of a moraine, 17.3% of 2199 blocks of axe principal d'une longueur > 30 cm presentent une forme de roche moutonnée. La proportion des blocs présentant leur face fente vers l'antérieur du glacier, à ± 22.5° de l'écoulement de la glace, s'éleve à 72.7%. Ainsi l'orientation préférentielle du moutonnement est fortement corrélée au mouvement de la glace et indique d'où vient le glacier. Seulement 11.7% des roches moutonnées s'écartant de cette orientation sont situés en rapport aux moraines annuelles. On suggère que de telles roches ont principalement été redéposées sous la glace et non au front à la suite d'avances secondaires du glacier.
The survey at Myrdalsjökull reveals that many clasts with a stoss-lee form also show a significant modification of their lower surfaces (henceforth termed a "double stoss-lee form"). It should be noted that the orientation of the stoss-lee form on the lower surfaces is opposite to that of the upper ones; the lower surfaces have a smoothed down-glacier face and a truncated up-glacier face.

A generalized picture of the formation of the double stoss-lee form is suggested in Figure 2. The lower down-glacier face of a clast which moves over abrading, already deposited till materials during basal transport is abraded and streamlined, while the lower up-glacier face is unaffected by erosion or is shaped by fracture. After deposition of the clast by ploughing into the till bed, but before the clast becomes buried by lodgement of debris, the abrading debris-laden glacier sole passes over its upper surface. By this means the upper up-glacier face is smoothed and streamlined, while the upper down-glacier face becomes truncated. Thus, the double stoss-lee form is interpreted as a response to basal transport being abraded and streamlined, while the upper surface. By this means the upper up-glacier face is smoothed and streamlined, while the upper down-glacier face becomes truncated. Thus, the double stoss-lee form is interpreted as a response to basal transport being abraded and streamlined, while the upper down-glacier face becomes truncated. Thus, the double stoss-lee form is interpreted as an overridden ice-marginal moraine (Krüger and Humlum, 1981). The ridge is interrupted where a former melt-water stream flowed through it. Furthermore, a series of annual moraine ridges, which trend parallel to the former locations of the ice margin, indicate that the ground moraine was exposed by frontal retreat of the glacier. The many flutes occurring within the selected area are evidence of an ice-flow direction approximately south-south-west to north-north-east.

Embedded boulders larger than 0.3 m in diameter were selected and mapped. The presence or absence of a stoss-lee form was recorded for each clast and, if it had a stoss-lee form, its orientation relative to the ice-flow direction was indicated on the map. In this manner a total of 2199 boulders was mapped.

The spatial distribution of boulders as shown in Figure 3 demonstrates that they occur sparsely on the ground-moraine surface. In several instances, lines of boulders frequently composed of two to four boulders trend parallel to the glacier-flow direction. They probably resulted from subglacial lodgement of clasts against already lodged clasts (Boulton, [1975]; Krüger, 1979). It can be seen that boulders...
are not concentrated particularly along the annual moraines. A possible explanation is that these small ridges have been formed by glacier-induced folding of subglacially deposited till along the glacier front and not by scraping pro-glacial material together at the glacier margin (Krüger and Humlum, 1981; paper by J. Krüger in preparation).

As much as 17.3% of the mapped boulders had a stoss-lee form. The proportion of clasts with their smoothed and streamlined ends facing up-glacier within ±22.5° of the ice-flow direction is 72.7%, showing that they can be used as indicators of ice-flow direction. Only 1.9% had their stoss-sides facing down-glacier. The stoss-side orientations of 94 of the 370 stoss-lee-shaped boulders were highly variable and diverged from the ice-flow direction. However, the idea that such boulders had been re-deposited by minor advances of the ice front responsible for constructing small push moraines does not find support in the present study; only 11.7% of the boulders with divergent stoss-side orientations are located in connection with annual moraines.

CONCLUSIONS

It is suggested that the presence of clasts with a double stoss-lee form is a diagnostic criterion for subglacial deposition by lodgement. Furthermore, it is concluded that the preferred stoss-side orientation of clasts with the development of a stoss-lee form on their upper surfaces indicates the direction from which the ice came. Stoss-side clasts with their highly variable and divergent orientation relative to the ice-flow direction have mainly been re-deposited beneath the ice and not at the ice front by minor advances of the glacier.

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REFERENCES


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