SIR, *Internal structure of the accumulation area of a glacier and the use of the term "foliation": comments on the paper by M. Vallon, J.-R. Petit and B. Fabre*

IN a recent paper, Vallon and others (1976) described the internal structure and fabric of the accumulation area of the Vallée Blanche in the Massif du Mont Blanc as revealed by ice cores. Only a few studies of the internal structure of temperate glaciers have been made, hence these observations are of particular interest from the point of view of ice deformation.

The authors described much of the ice in the cores as "foliated" and concluded that "the foliation has a sedimentary, and not a tectonic origin". Whilst not wishing to dispute the origin of the layering in their ice cores, I am unhappy about the use of the term "foliation" in the above sense. In geological literature, foliation by definition must be the result of deformation. For example, Turner and Weiss (1963, p. 28) defined it "by the metamorphically produced surfaces of discontinuity in deformed rocks", and it includes such structures as cleavage and schistosity. Similarly, previous descriptions and definitions of foliation in ice imply that it is a secondary planar structure produced by flow or strain (e.g. Sharp, 1954; Allen and others, 1960; Meier, 1960; Taylor, 1962; Ragan, 1969). Texturally, it consists of intercalated layers of coarse bubbly, coarse clear and fine-grained ice (cf. Allen and others, 1960). It seems, therefore, that the term "foliation" is best restricted to features of deformational origin. If a stratified structure is observed in glacier ice, why not call it simply stratification or sedimentary layering (e.g. Grove, 1960; Ragan, 1969)?

Although the continuity and regularity of individual layers is sometimes a distinctive feature of stratification in ice, it is often difficult to distinguish it from foliation; this is why there has been so much controversy for well over 100 years concerning the origin of layered structures in glaciers. In some places one can see that an early layering (stratification) is cut by another structure (foliation); it is then clear that deformation produces the second structure. Sometimes, however, one can make conclusions on the origin of the layering only after considering the disposition of all structures and the probable flow conditions in a particular glacier. In some glaciers, one finds that foliation is parallel to the stratification, as observed by Ragan (1969) in an Alaskan valley glacier and, more extensively, by the writer in Norwegian cirque glaciers (Hambrey, 1975). Deformation is also important in such instances, because shearing is believed to take place in the planes of the existing layers when the strain conditions are favourable, i.e. the precise orientation of the foliation is controlled by a pre-existing planar anisotropy.

Following further work on ice structures in Swiss valley glaciers, it seems to me that deformation is generally great enough to destroy the original stratification at an early stage, and one may not be able to recognize it at all in the ablation area. Thus, structural and fabric analyses of cores taken at various positions on a longitudinal profile from the upper accumulation area to the ablation area should give most interesting information concerning progressive deformation, particularly if the orientation of the cores can be ascertained and if surface structures and strain conditions can be determined simultaneously. One hopes that such a study can be made in the not too distant future!

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