Frederickson's statements of evidence against the phenomena of "channels" being due to mounting media (pp. 825–6) are as follows:

1. The relief features of calcite and other mineral grains change during rotation of the stage.
2. Optically polished surfaces on the thin sections did not eliminate the "channels."
3. Old slides also show "channels."
4. Several different mounting media yield the "channels."

It would appear to the authors that the variation in relief of calcite with rotation of the stage (p. 825) merely indicates that the lighting used enhances the relief features to be expected from a highly birefringent mineral like calcite and proves nothing about origin of the "channels." The presence of "channels" even with optically polished surfaces on the thin section does not eliminate the possibility of mounting media variations which could still appear as "truly an optical phenomenon." The presence of "channels" in old slides is merely a result of the use of the same mounting medium (balsam in xylol), in that diffusion boundaries in balsam, once arrested by cooling, may exist for years. As to the use of other mounting media, any media involving two materials of different index such as a resin (balsam) and solvent or plasticizer (xylol) will give gradients in index wherever composition gradients exist, and hence will show "channels."

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CHANNELS IN THIN SECTIONS—A REPLY*

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Messrs. Stringham and Roedder (1954) have commented on my paper (Frederickson, 1953*a*) which illustrated the fact that inclined transmitted illumination revealed much more detail in thin sections than vertical illumination techniques. It is gratifying to find that they confirm this view.

Their comments are primarily directed, however, at some of the details shown in the photomicrographs in spite of the fact that in the original paper (p. 826) it was explicitly stated that

"No attempt would be made . . . to 'explain' the origin and significance of the 'channels.' "

The word channel was enclosed in quotes and was intended to mean a passageway in the rock or mineral through which matter may have

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FIGURE 1

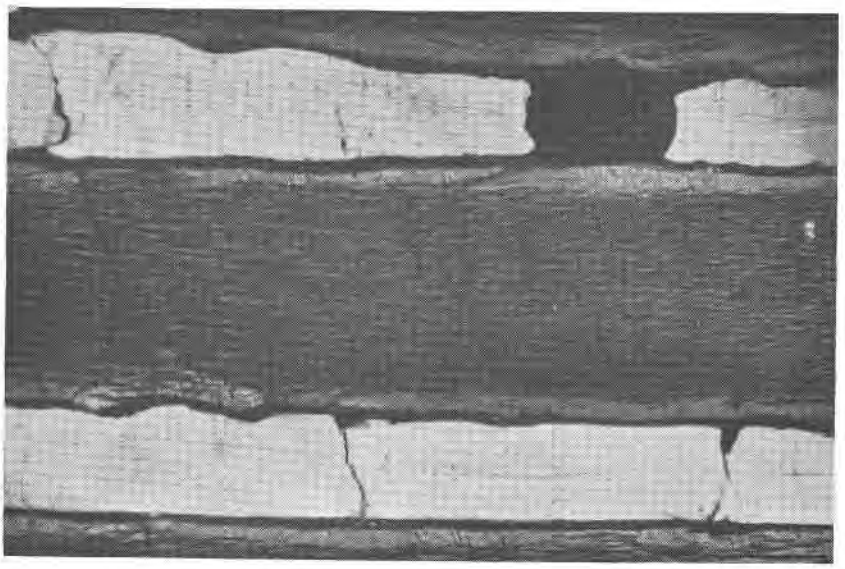

FIGURE 2

moved. They are quite correct in stating that any differences in index of refraction, including those produced by variations in the mounting media, may produce Becke lines and features much like those shown in the figures in my paper. They are not correct, however, when they deny that actual channels exist in the rocks. The alteration in Figs. 5 and 6 (Frederickson, 1953*a*) is intimately related to the crack, suture or grain boundary in the quartz (not produced during sample preparation) outlined by the channel at the top; the elliptical-shaped low-relief area in Figs. 7 and 8 outline sericite-filled holes which admitted late solutions. These are actual channels that existed long before the thin sections were prepared.

The photomicrographs included here clearly support the conclusion that much has happened to the minerals along these passageways or channels outlined by the Becke lines. Figures 1 and 2 (Magnification 73×) show quartz stringers forming a graphic texture with perthitic microcline. A double rim of recrystallized feldspar can be seen around the edges of the quartz. The rim adjacent to the quartz has a different optical orientation from the rest of the feldspar (note the black rims in the crossed-nicol photomicrograph). The next rim has the same orientation as the host microcline, but is free from perthite lamellae. Note that the cleavage cracks extend through both of the feldspar rims and abut against

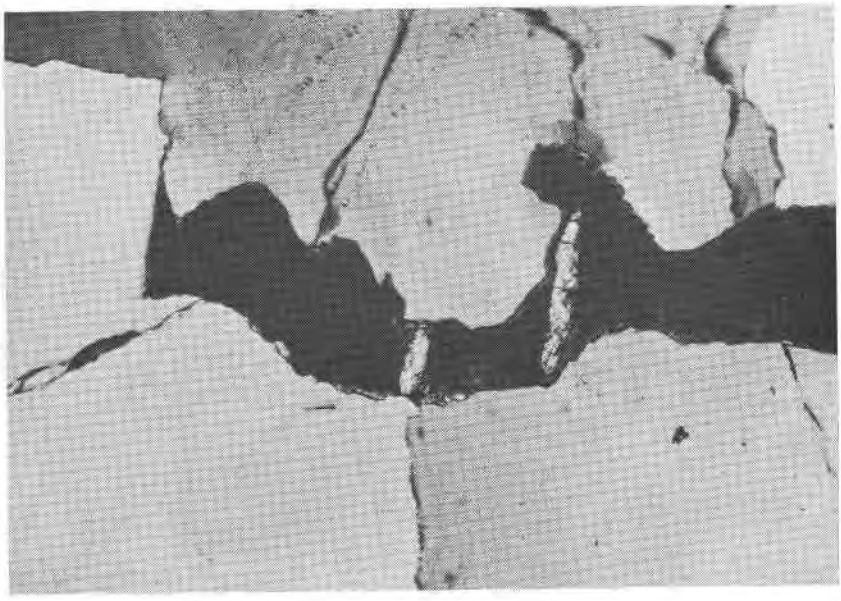

FIGURE 3

the quartz. Whether this recrystallization is due to the introduction of the quartz itself or to solutions moving along the quartz edges (along channels), is a matter which will be discussed when the petrology of these rocks is presented.

Figure 3 (Magnification 78×) shows a dark mineral (biotite) bounded by quartz. Numerous channels exist in the quartz. Where some of the channels cross the biotite, large, cigar-shaped clinozoisite crystals have developed. The edges of the biotite crystal are streaked. The streaking is most intense around the channels and grades inward. The color of the biotite changes from deep brown to almost colorless. Iron and magnesium have been removed from the biotite and clinozoisite crystals have developed. The spatial relationship of these secondary features to the cracks or channels outlined by Becke lines is highly suggestive that these are the passageways along which materials added to or subtracted from the minerals have moved.

Figure 4 (Magnification 157×) shows a rectangular zoisite crystal developing in oligoclase. The zoisite crystal is zoned. The zoisite has developed in the oligoclase at the "mouth" of a channel in the quartz. Many "streams" of what appears to be the same kind of material occurs in partings perpendicular to the twin lamellae. Some of this is zoisite but some is also micaceous, probably sericite. Tiny specks of this zoisite

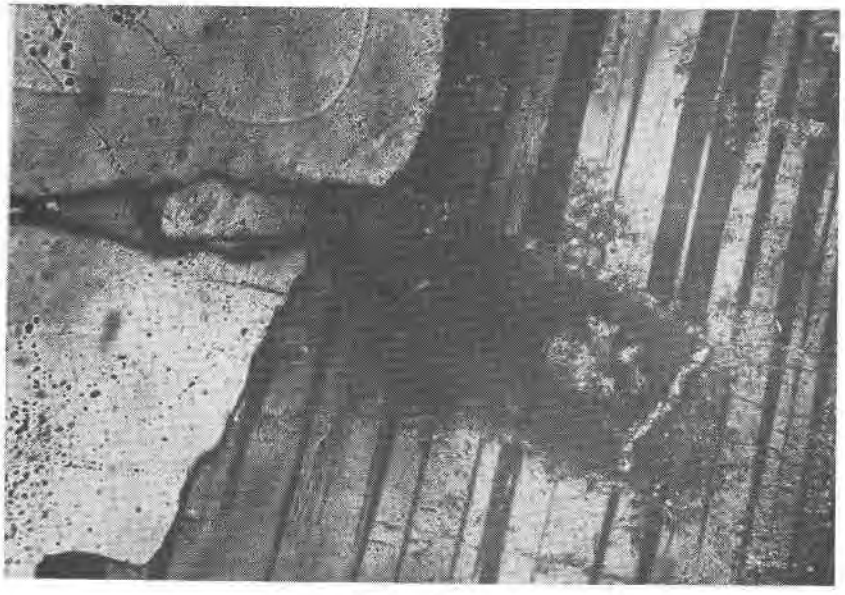

FIGURE 4

and sericite-like material occurs within the channel. The passageway or channel along which some of this material has apparently moved is clearly not a fortuitous crack with a significance related only to the method of preparation of the thin section.

Diluted balsam working up along cracks or natural crystal boundaries could, and does, produce index differences that outline cracks and holes in the section. In my original paper, however, I stated that I *thought* that Becke lines outlining some channels were actually due to compositional differences in the mineral itself. I still think this is correct. However, the statement should not have been made without the accompanying evidence to support it. Some of the supporting evidence (Frederickson, 1953 *b* and *c*) occurs in other papers which have been in the hands of the editor of this Journal since September and October, 1953. The best evidence supporting this conclusion results from etching tests, using pure water under elevated pressures and temperatures, on quartz and various other minerals. Actual channels can be produced in quartz crystals (Fig. 6, Frederickson, 1953*b*) by suitably etching them with water. These channels represent zones of greater solubility than the bulk of the crystal. These channels are real: a small wire can be stuck into them. The crystals are unmounted, hence the existence of the channels cannot be questioned in terms of the method of mounting or mounting media variations. Similar channels have also been produced in albite, anorthite and microcline by hydrothermal etching techniques.

Summary: (1) As shown in the accompanying photomicrographs, channels or passageways along which materials or solutions have moved and which are features of the rock itself, exist as originally stated.

(2) These channels may be outlined by mounting media which can work up along them to produce some of the features shown in the photomicrographs. Some channels, however, but by no means all, are independent of the variations in the mounting media and are related to differences within the minerals themselves. Evidence documenting this opinion for quartz is now in press and details for anorthite and microcline are in preparation.

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