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Trip G-5

TILL STUDIES, SHELBURNE VERMONT

by

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INTRODUCTION

In the summary report of the Vermont Geological Survey-sponsored surficial geology mapping program, Stewart and MacClintock (1969) presented the first comprehensive Laurentide stratigraphy for the entire state. Surface tills in three regions are differentiated primarily on the basis of till fabric. In a streambank exposure near Shelburne village in northwestern Vermont their "Burlington till"(northwest fabric) is reported overlying "Shelburne till"(northeast fabric)(Figure 1). This locality is the subject of this report. The report emphasizes till fabric measurements but other parameters are included: color, texture, lithology, particle shape, heavy minerals, and striae. The bulk of the data is from the exposure previously studied by Stewart and MacClintock but nearby exposures were also sampled.

Acknowledgements

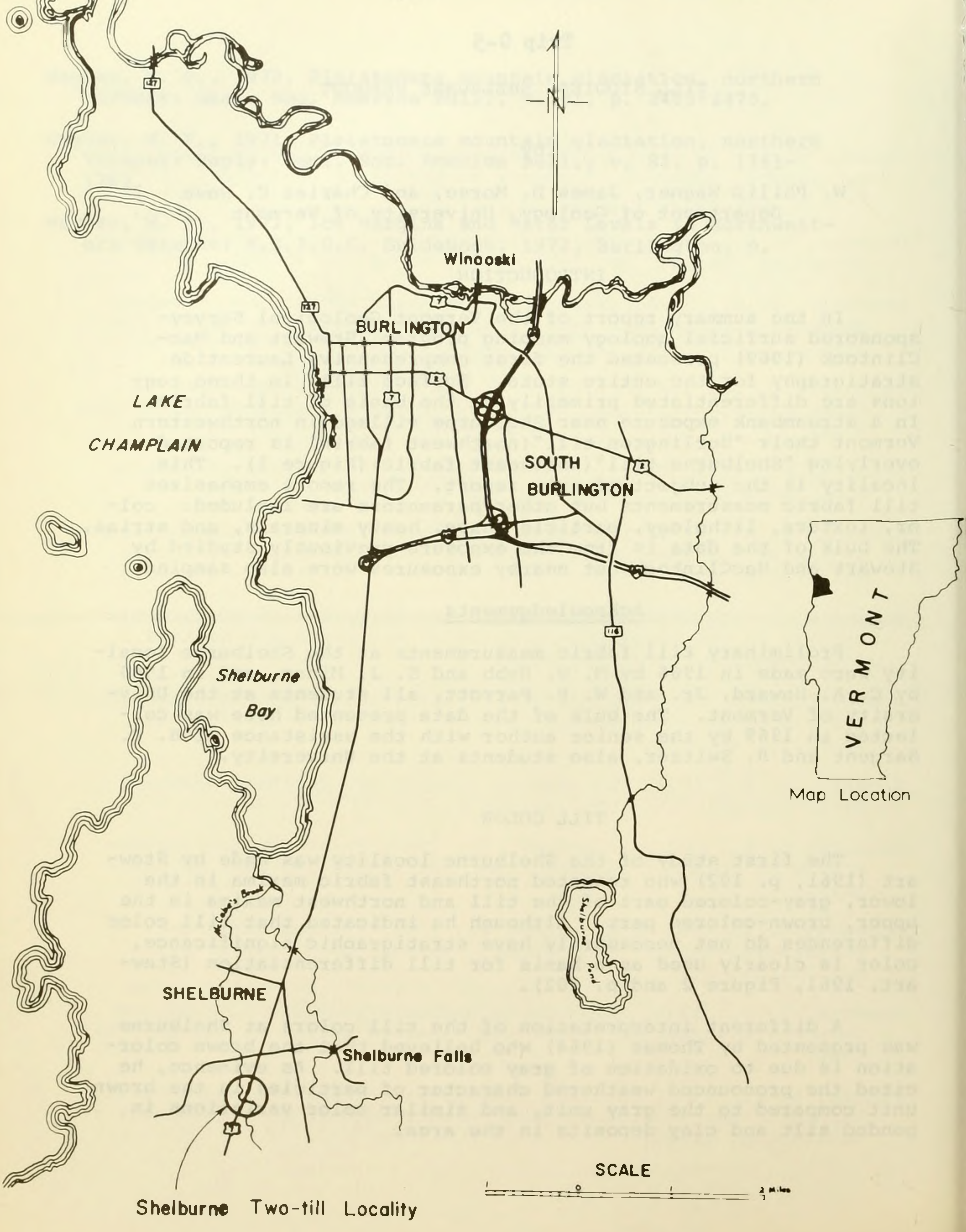
Preliminary till fabric measurements at the Shelburne locality were made in 1966 by M. W. Hebb and S. J. Minor, and in 1969 by C. A. Howard, Jr. and W. R. Parrott, all students at the University of Vermont. The bulk of the data presented here was collected in 1969 by the senior author with the assistance of B. P. Sargent and R. Switzer, also students at the University.

TILL COLOR

The first study of the Shelburne locality was made by Stewart (1961, p. 102) who reported northeast fabric maxima in the lower, gray-colored part of the till and northwest maxima in the upper, brown-colored part. Although he indicated that till color differences do not necessarily have stratigraphic significance, color is clearly used as a basis for till differentiation (Stewart, 1961, Figure 2 and p. 102).

A different interpretation of the till colors at Shelburne was presented by Thomas (1964) who believed that the brown coloration is due to oxidation of gray colored till. As evidence, he cited the pronounced weathered character of particles in the brown unit compared to the gray unit, and similar color variations in ponded silt and clay deposits in the area.

Figure 1. Location of till exposure.



From our study of the Shelburne exposure the following observations can be made about the color difference. Munsell color codings of wet samples are 10 YR 2/1 and 10 YR 3/4 for the gray- and brown-colored till units respectively, with relatively slight intra-unit variations. The contact between the brown and gray colors is sharp. Lenses of gray-colored till are surrounded by brown-colored till, and brown coloration extends downward along joints for several feet into the gray-colored unit. In this and numerous other exposures in the region showing similar brown-and gray-colored till, the contact between the two units generally appears to reflect the slope of the overlying ground surface. These aspects indicate to us that the color difference can be better explained by weathering, as Thomas suggested, than by multiple glaciation. Furthermore, our attempts to differentiate the brown- and gray-colored tills with a variety of parameters, including fabric, have been unsuccessful, thereby lending support to the view that multiple glaciation is not the cause of the color difference.

FABRIC

Stewart (1961, p. 102) reported fabric maxima (based on a 180 degree, two-dimensional reference system) of N30E and N15W for the gray- and brown-colored tills, respectively. Thomas' (1964, p. 68-72) fabric study of the same exposure showed N25W and N45W maxima for gray and brown units, respectively. He also measured fabric at a nearby exposure of gray-and brown-colored till, both of which had preferred north-south orientations. In unpublished fabric studies at the same locality, students from the University of Vermont consistently have found northeast maxima in the gray-colored till; in the brown-colored till, on the other hand, most fabrics showed bimodal distributions with northeast and northwest concentrations of varying relative strengths.

In the work reported here ten fabric analyses were made at the Shelburne locality (Figure 2). Eight of the sites were from two vertical trenches excavated to assure undisturbed samples, and two sites were at the middle and upper central parts of the exposure. A hand-held Brunton compass was aligned parallel to long axes of elongate particles to measure azimuth and inclination. In addition, the orientation of blade-and disk-shaped particles was determined by measuring the strike and dip of a plexiglass plate oriented parallel to flat particle sides. Thus, only azimuth and inclination were measured for rod -shaped particles, only strike and dip for disk-shaped particles, but both spatial factors were measured for blade-shaped particles. Long axis measurements are probably accurate to $\pm$ 5 degrees, whereas strike-dip data are somewhat less accurate.

The data were originally plotted in the field on Schmidt equal-area stereo nets. This showed that most fabric patterns are polymodal, thus making statistical reduction difficult. To facil-

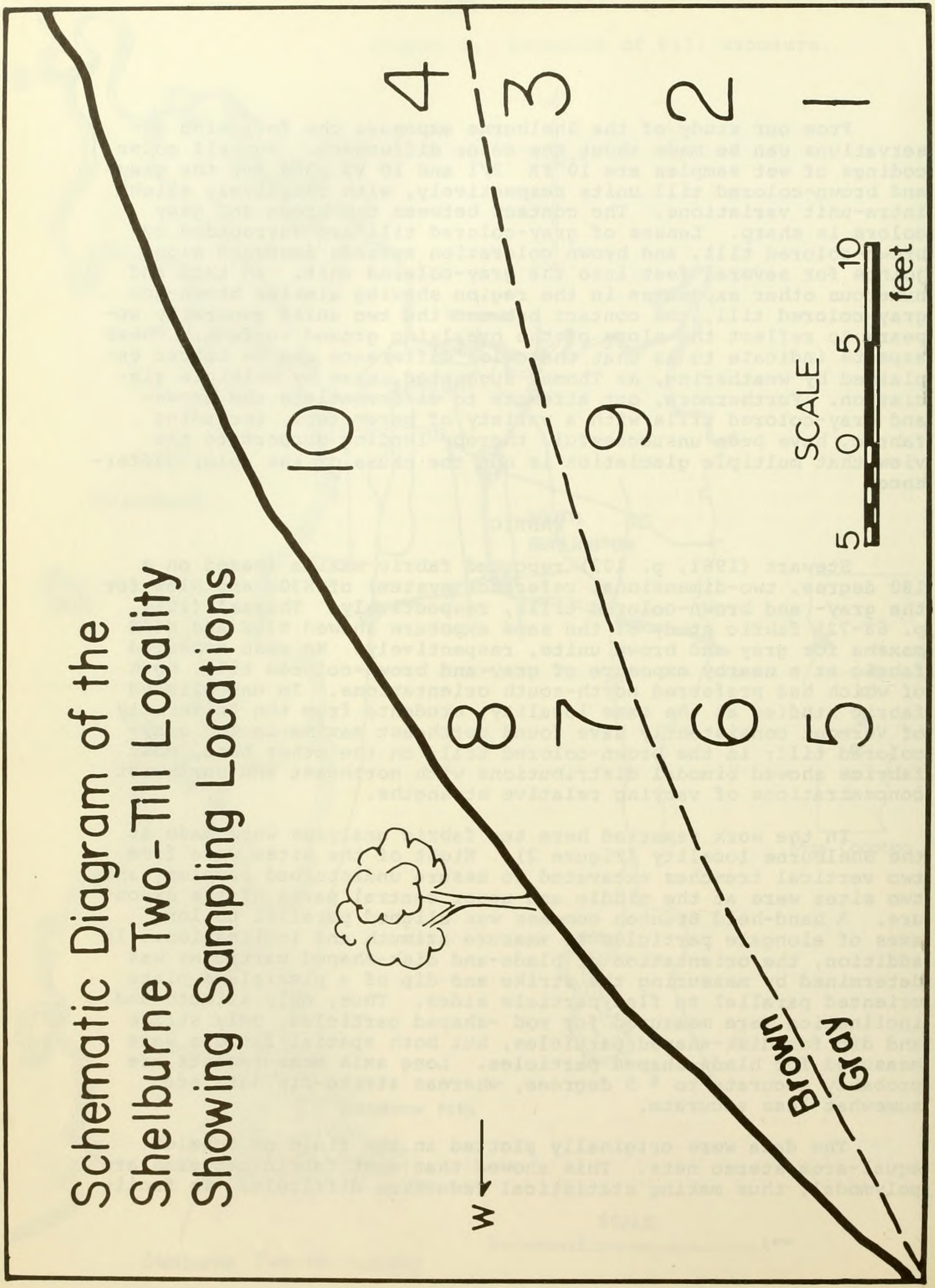


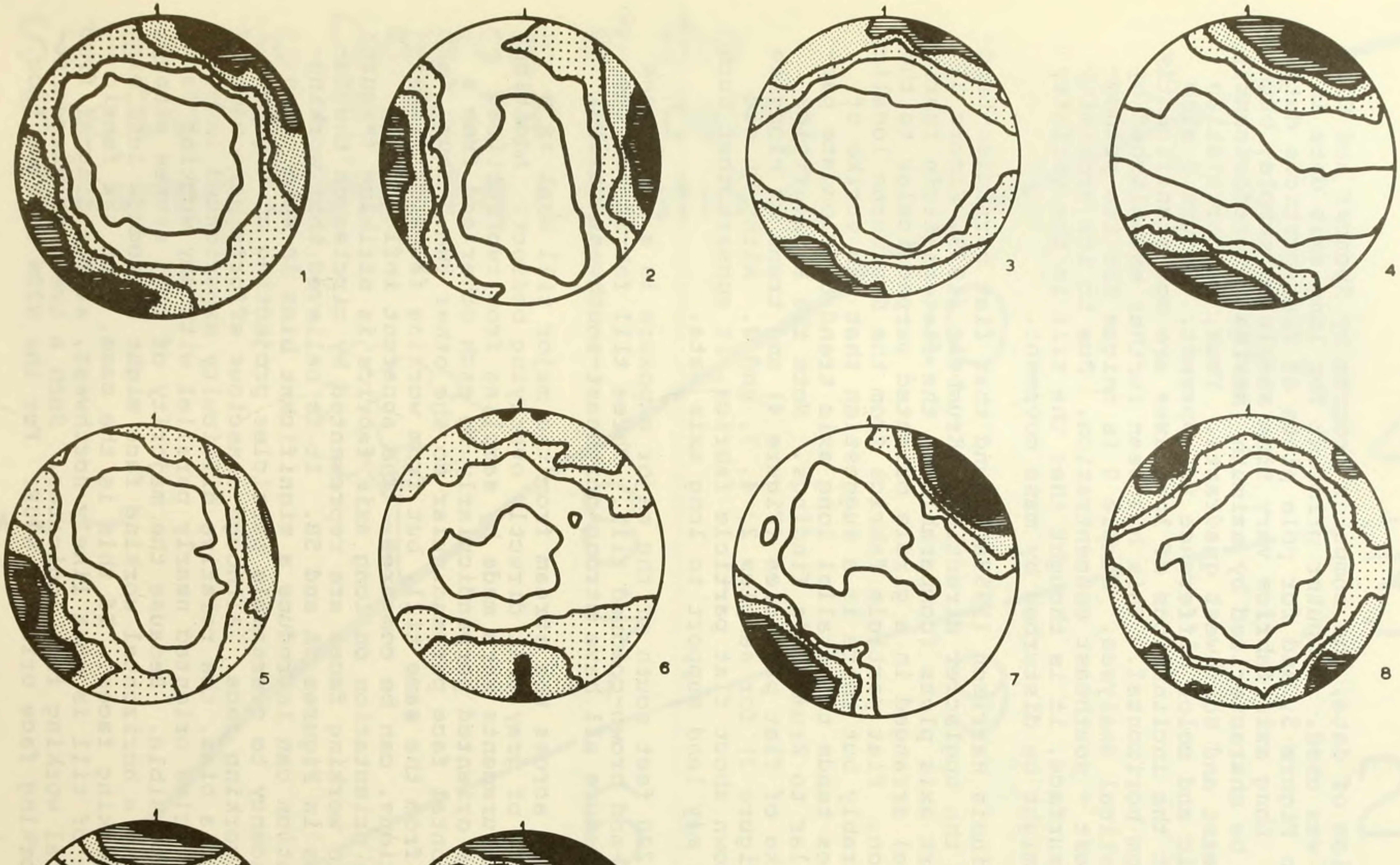
Figure 2. Schematic view of till exposure.

itate reduction of data, the computer program by Spencer and Clabaugh (1967) was used. Computer printout for long axis data is reproduced in Figure 3, and for pole plots of flat particle data in Figure 4. Long axis fabrics vary from sample to sample, but most tend to be characterized by azimuth maxima predominantly in the northeast and southwest quadrants. Thus, no correlation between fabric and color difference is apparent. Figure 3 also suggests that the inclinations of long axes are not significantly different from horizontal. This has been further established by simple statistical analyses. Sample 8 is unique for its predominant northwest - southeast concentration. Due to its proximity to the land surface, it is thought that the till in the vicinity of sample 8 might be disturbed by mass movement.

In Illinois Harrison (1957a) found that flat particles tended to dip in the upglacier direction. Krumbein (1939, Figure 3) depicted short axis plots (comparable to the flat particle fabrics reported here) arranged in a girdle oriented perpendicular to the flow direction. Flat particle fabrics from the Shelburne locality vary considerably but there is a suggestion that the strike of flat particles tends to parallel long axis trend of elongate particles, similar to Krumbein's findings. Note the similarities between strike of flat particles (Figure 4) and trend of elongate particles (Figure 3) for samples 2, 4, 7, and 8. Although not enough is known about flat particle fabrics, it appears that such measurements may lend support to long axis data.

About 200 feet south of the major exposure is a streambank showing gray-and brown-colored till. Three till fabric samples from this exposure all have strong northeast-southwest maxima.

Directly across the stream from the major till bank is a small exposure of gray till directly overlying bedrock. Additional fabric measurements were made by sampling from two vertical working faces oriented perpendicularly to each other and from a third, horizontal face perpendicular to the other two. Thus, fabrics taken from the same till, but from working faces of different orientations, can be compared. The apparent influence of working-face orientation on long axis fabrics is striking (Figure 5). Poles to working faces are represented by circles on the fabric diagrams in Figures 5A and 5B. It is believed that working-face orientation can introduce a significant bias in some cases due to a tendency to oversample particles projecting at high angles to the working face. Although conscious efforts were made to avoid such a bias, the relative difficulty experienced in extracting particles oriented nearly parallel with any working face made this impossible. Because the majority of till stones plunge at low angles, a horizontal working face might introduce less bias than other working faces. If this is the case, then the fabric of this cube of till is most likely northwest, as the diagram from the horizontal working face indicates. Such a trend is exaggerated by the working face oriented N70E. For the N20W working face,



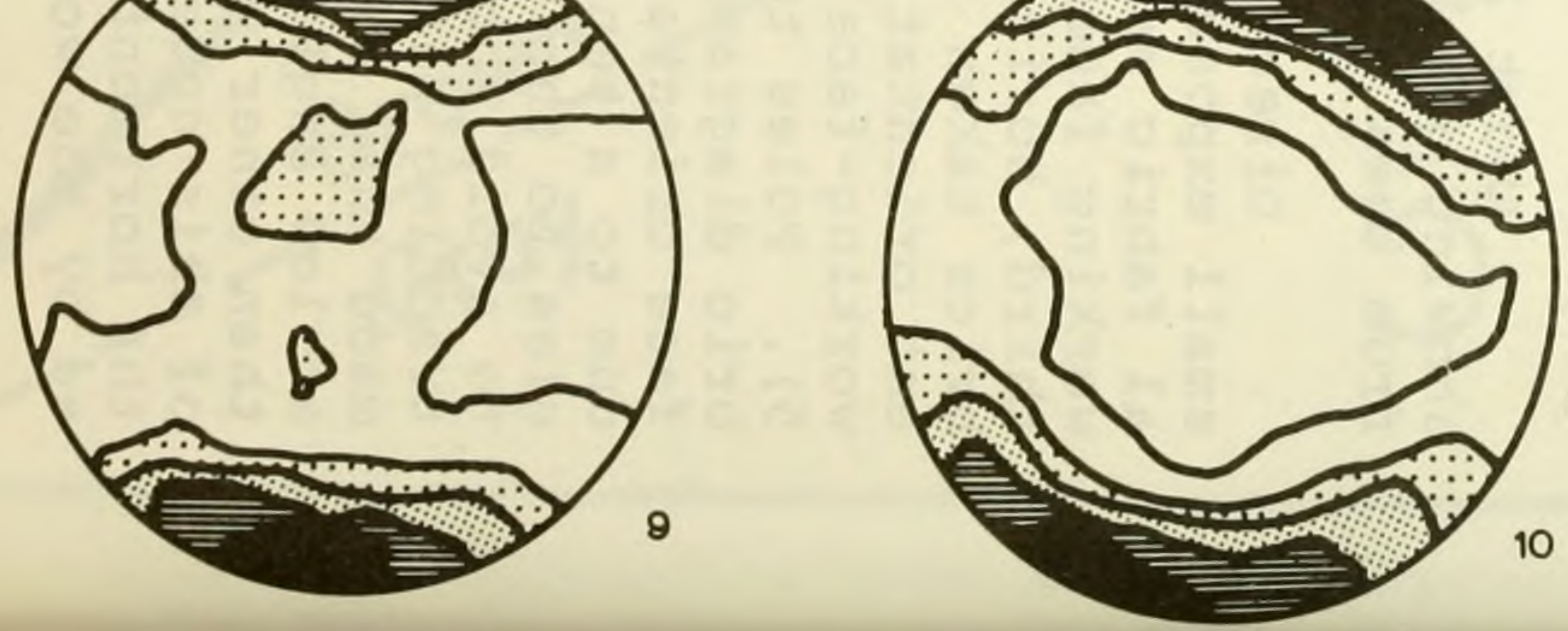
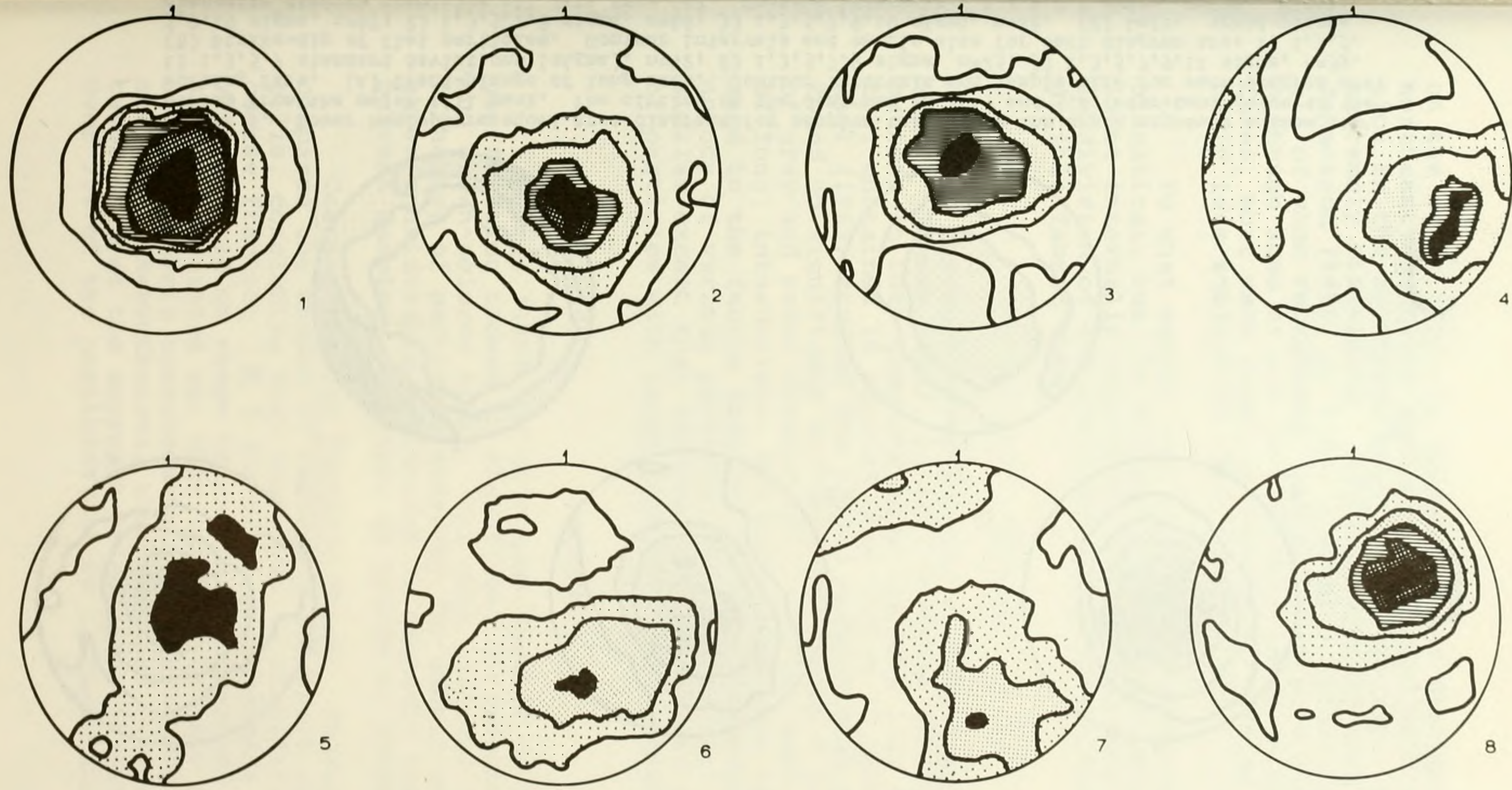


Figure 3. Lower hemisphere equal area diagrams for trend-plunge of long axes. Numbers refer to the sampling locations shown in Figure 2. Contour intervals and sample size for each diagram are: 1) 1,3,5,7,8 standard deviations (sigma), n=55; 2) 1,3,5,7,9 sigma, n=40; 3) 1,3,5,7,8 sigma, n=49; 4) 1,3,5,7,9 sigma, n=31; 5) 1,3,5,7,8 sigma, n=38; 6) 1,3,5,7 sigma, n=32; 7) 1,3,5,7,9,10 sigma, n=43; 8) 1,3,5,7,8 sigma, n=74; 9) 1,3,5,7,9 sigma, n=38; 10) 1,3,5,7,9,11 sigma, n=63.



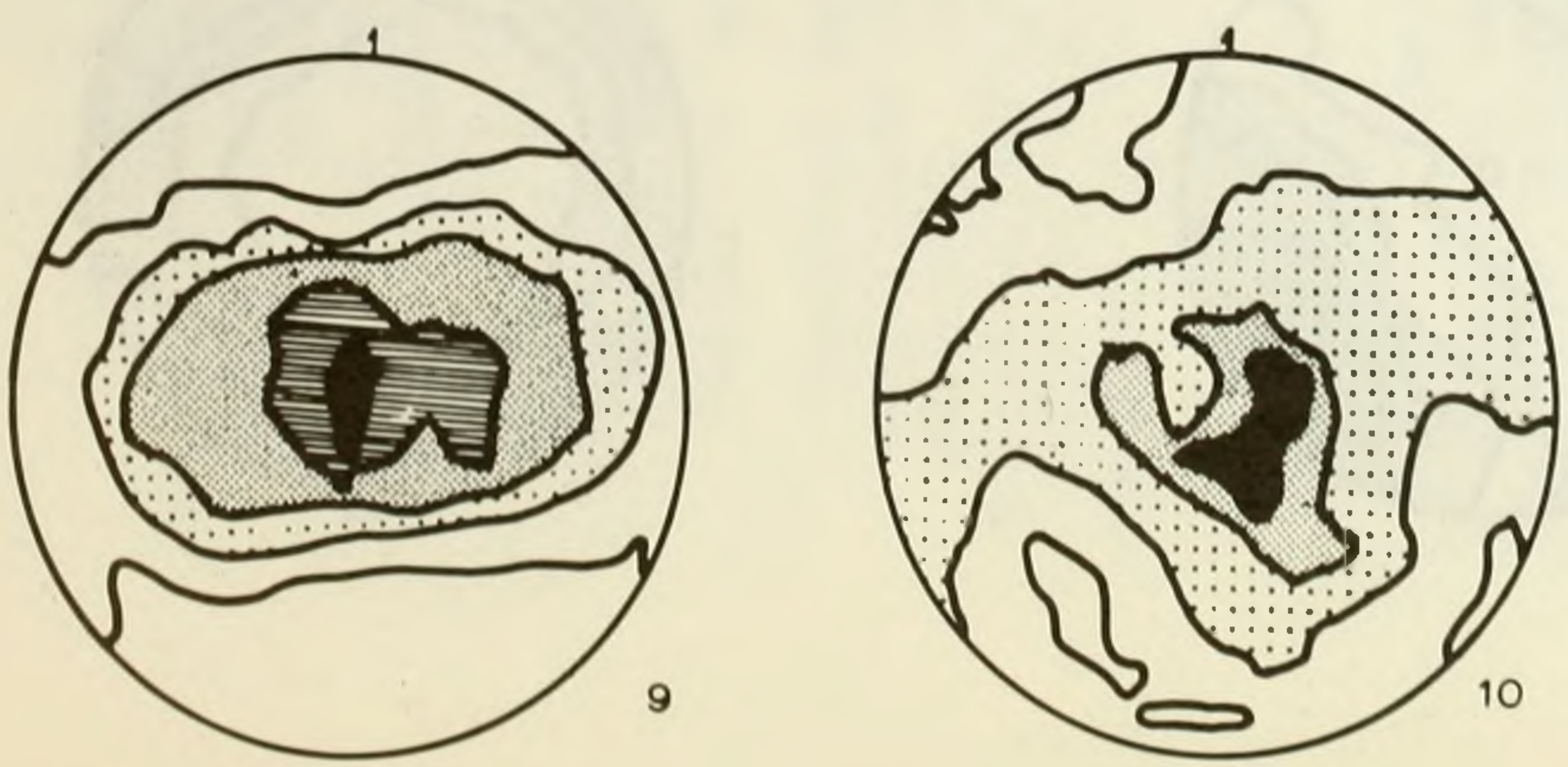


Figure 4. Lower hemisphere equal area diagrams for strike-dip of flat particles. Numbers refer to the sampling locations shown in Figure 2. Contour intervals and sample size for each diagram are: 1) 1,3,5,7,9,11 standard deviations (sigma), n=29; 2) 1,3,5,7,9,10 sigma, n=47; 3) 1,3,5,7,9 sigma, n=34; 4) 1,3,5,7,8 sigma, n=30; 5) 1,3,5 sigma, n=23; 6) 1,3,5,7 sigma, n=44; 7) 1,3,5,7, sigma, n=29; 8) 1,3,5,7,9,10 sigma, n=57; 9) 1,3,5,7,9 sigma, n=34; 10) 1,3,5,6 sigma, n=69.

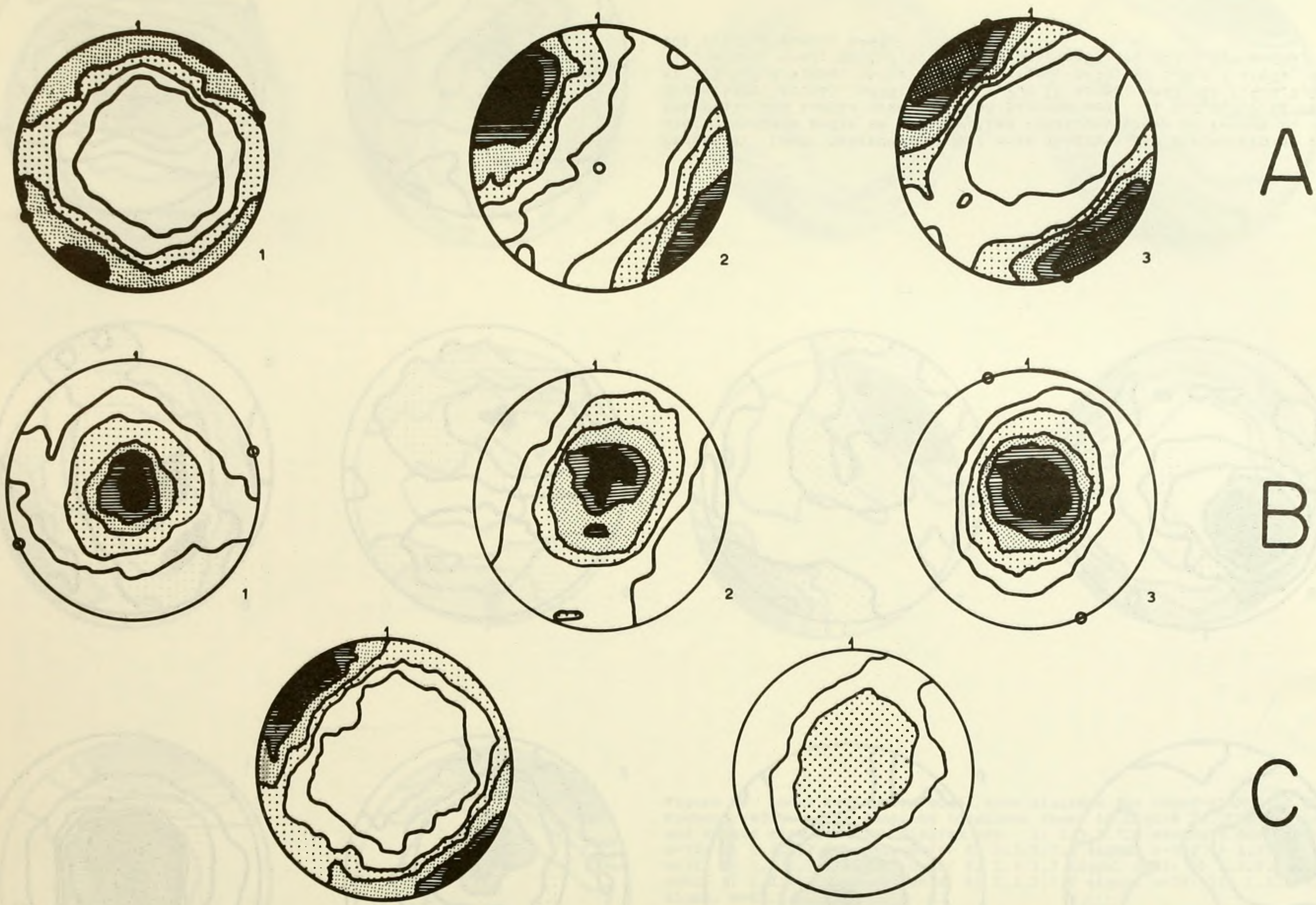


Figure 5. Lower hemisphere equal area diagrams for samples taken from the small exposure across the stream from the major till bank. The circles on the diagrams in 5(A) and 5(B) represent poles to the working face. (A) Trend-plunge of long axes. Contour intervals and sample size for each diagram are: 1) 1,3,5,7 standard deviations (sigma), n=42; 2) 1,3,5,7,9 sigma, n=25; 3) 1,3,5,7,9,11 sigma, n=39. (B) Strike-dip of flat particles. Contour intervals and sample size for each diagram are: 1) 1,3,5,7,9,10 sigma, n=67; 2) 1,3,5,7,8 sigma, n=26; 3) 1,3,5,7,9,10 sigma, n=28. (C) Left: trend-plunge composite diagram combining all data from (A). Contour intervals: 1,3,5,7,8 sigma, n=106. Right: Strike-dip composite diagram

on the other hand, it appears that a dominant but artificial northeast-southwest maximum is created with a lesser concentration in the northwest-southeast quadrants. Such a pattern is extremely misleading. Similar findings have been reported by Johansson (1968, p. 206), Dreimanis (1959), and Thomas (1964), all of whom recognized sampling bias as a significant problem. Although some of our fabrics were taken on non-horizontal working faces, most were taken on horizontal working faces, which are probably less subject to this type of bias.

To what extent till fabric measurements are reliable is problematical, but the dominantly northeast-southwest mode is at least internally consistent. It is our view that stratigraphic subdivision of the Shelburne exposures is not supported by reproducible fabric data.

TEXTURE

No thorough investigation of till texture was made in this study. Thomas (1964, p. 135) reported similar grain size distributions in both gray- and brown-colored till except that the brown till contained 10 percent clay versus 25 percent in the gray till. Kodl (1967) studied the -2Ø to greater than 4Ø size range and found no significant differences between a total of six samples of gray- and brown-colored till. In our work, caliper measurements of long, intermediate, and short axes were made of all particles used in the fabric analysis. Visual inspection of graphs of frequency of various particle sizes showed that all samples appeared similar except that samples 7 and 8 contain a higher proportion of particles with large long axes than other samples.

LITHOLOGY

Thomas (1964, p. 165) measurements of lithology of the granule fraction showed no significant differences between the gray- and brown-colored tills. Our work included identification of the lithology of particles selected for fabric analyses. This data shows considerable variations in particle lithology percentages between samples. However, no trends or patterns are apparent.

<u>Coarse Fraction Particle Shape</u>: Thomas (1964, p. 76-89) compared the shapes of carbonate and shale granules in the two tills, concluding that there was no significant difference. The coarse fraction (≳ 3.3Ø) axial measurements from this study were plotted on shape triangles as described by Folk (1964). It should be pointed out that inasmuch as only those particles suitable for fabric measurements were considered, equant grains were excluded. Nevertheless, the procedure used was similar in all cases so that the approach is at least internally consistent. Over 90% of the particles can be circumscribed by 0.2 - 0.5 short:

long axial ratio values and by 0.1 - 1.0 long-minus intermediate: long-minus short axial ratio values. A notable exception to this is sample number 8 which includes a larger proportion of compact particles than any other sample. It appears that this anomaly cannot be explained lithologically and is believed to be a significant, difference between samples.

Heavy Mineral Analysis: Heavy mineral separations of the medium sand-sized fraction were conducted by Caldwell (1969) on single samples from each of the brown and grey tills. Using bromoform (sp.gr.$\gtrsim$ 2.85), amounts of 81.4% and 77.2% dolomite were counted in the heavy fraction of brown and gray till samples, respectively. Although the dolomite contents do not appear significantly different, Caldwell noted that dolomite in the brown till had a "pinkish-orange" color thought to be due to oxidation of the brown till. Removal of the dolomite by iodide-acetone separation (sp.gr.$\approx$ 3.0), facilitated identification of the non-dolomite fraction, but no pronounced differences between the tills were found. Also, no significant differences of magnetic fractions were detected.

Clay Fraction Mineralogy: A preliminary X-ray diffraction analysis of the clay fraction was made by Parrott (1968). Sixteen samples spanning the contact between the gray- and brown-colored tills were taken to determine if any differences between the tills could be detected. Parrott found a deficiency of calcite near the top of the exposure, and a calcite concentration at slightly greater depth, both of which he attributed to leaching. Chlorite generally decreases upward, and muscovite, montmorillonite, and an unidentified mixed-layer mineral increase upward. Kaolinite content is lowest just above the color contact. Plagioclase is highest at the middle of the exposure, near the contact. Parrott (1968) concluded that no systematic differences between gray- and brown-colored tills could be found on the basis of clay mineralogy.

STRIAE

Glacial striae are well developed on a bedrock surface immediately south of the main till exposure and adjacent to the site where the data for the fabric diagrams shown in Figure 5 were collected. Two directions of striae are discernable. Over most of the outcrop surface only one set of striae are found with a N30W-S30E trend. In the most recently exposed part of the bedrock another set of striae oriented north-south appear. It is difficult to determine the relative age of the striae. The significance of the striae in relation to the main till exposure is unknown.

SUMMARY AND CONCLUSIONS

Our work on till fabric at the Shelburne - Burlington till locality does not support the two till view. Three independent investigations of till fabric at the site have produced different results. Moreover, we have failed to find evidence of stratigraphic difference on the basis of a variety of parameters. Drawing an analogy from the null hypothesis of statistics, no significant stratigraphic differences at Shelburne can be inferred until conclusively proven. We prefer to avoid the usage of the terms "brown till" and "gray till" in deference to adjectival expressions without stratigraphic overtones, i.e. gray- or brown-colored till.

Perhaps the most worthwhile information from this study relates to the subject of till fabrics in general. The suggested bias due to working face orientation indicates that the concepts of transverse and longitudinal fabric maxima may not be straight forward. For example, a vertical working face oriented nearly parallel to the direction of former ice movement might result in a tendency to undersample the longitudinal population while oversampling the transverse (refer again to Figure 5). Whole-till sampling techniques, as for example the method of Harrison (1957b), may be less misleading than our method of fabric measurement.

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