Clast fabric in a Stony Brook campus moraine: Testing models for the process of glacial lobe dynamics

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A layer of glacial till found along the north shore of Long Island and throughout the Stony Brook University campus, located in Stony Brook, New York, was deposited around twenty-two thousand years ago late in the Wisconsinan stage of the Pleistocene Epoch. The Stony Brook University campus is located on the Stony Brook moraine, which is part of the Harbor Hill-Roanoke Point-Fisher's Island-Charlestown Moraine, as can be seen in the digital elevation map (DEM) in figure 1. The till was presumably deposited on campus by the glacial activity of the Connecticut Lobe of the Laurentide Ice Sheet as it moved in a generally southern direction.

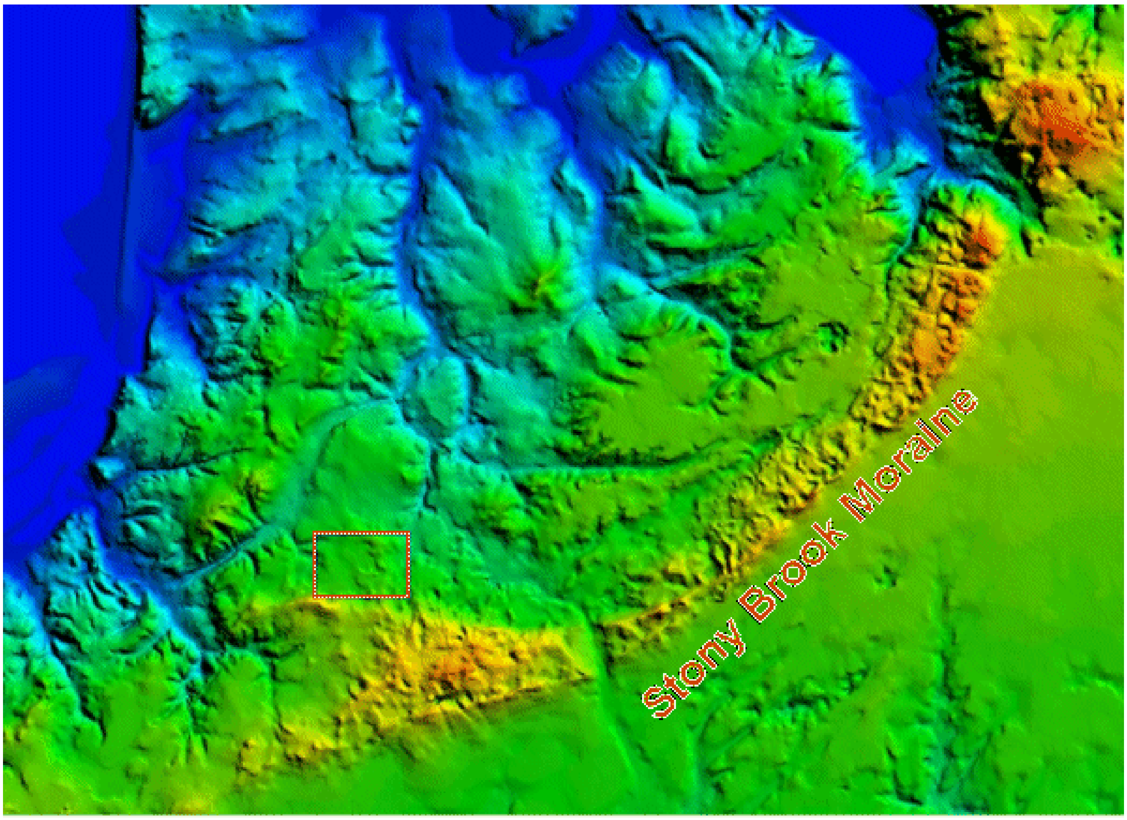

Figure 1 – A Digital Elevation Map (DEM) of the Stony Brook Moraine with a box outlining the approximate location of the study area located on the Stony Brook University campus.

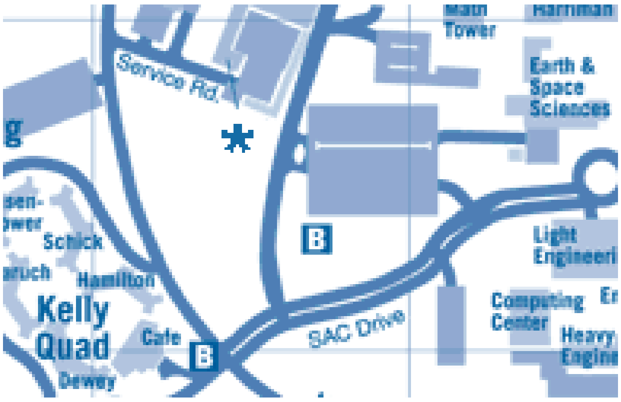

Figure 2 - A map of the Stony Brook University campus showing the approximate location of the study, marked by an asterisk (*).

Our study focused specifically on the arc shaped Stony Brook push moraine section of the Harbor Hill moraine, as seen in figure 1, located in the vicinity of Stony Brook, New York. Clast fabric orientation data was collected from till on the Stony Brook University Campus at a location west of the Earth and Space Sciences parking lot (see figure 2), in a wooded area adjacent to a small stream valley, possibly a small tunnel valley. The location selected was intended to consist of an undisturbed area of till within the push moraine. Laboratory experiments conducted by Tzakas et al. (2002), as well as numerous field observations, have indicated that the glacial sediments in a push moraine will display particular deformation features governed by the physics of the glacier's motion. The intention of this study was to determine if the direction of the Stony Brook push moraine, and the resulting deformation, could be observed through the orientation of the clast fabric within the till.

The subject area consisted of a trench measuring approximately three feet in depth and four feet in width. The area was hand dug to these dimensions so that the exposed till could be easily measured and so that it was undisturbed by root activity and possible slumping. The only criteria for collection of each clast consisted of selecting clasts that were approaching a rod-like shape; in other words, they exhibited a definite short, intermediate and long axis. So, sphere shaped clasts were not measured since they "have infinite combinations of three mutually perpendicular axes … make very weak fabric, have no preferred directions, and indicate little about emplacement or strain" (Klein et al., 2001). Therefore, elongated rods are the easiest shapes to measure in the field and are ideal clasts to indicate lineation of the fabric (Klein et al., 2001). Once a clast was selected from the subject area, the bearing and plunge of the long axis was measured. The tools utilized for this measurement included a Brunton compass and a T-junction apparatus.

During the course of our excavations of the till, we uncovered fifty clasts that met our selection criteria. After determining the long, intermediate, and short axis of the clast, we measured the bearing and plunge of the long axis using the Brunton compass and T-junction apparatus. The data that we collected for each clast has been summarized and presented in Table 1, found in the appendix. After the data was collected and compiled, we then used it to plot an equal-area stereographic scatterplot (Figure 3), an equal-area stereographic contour plot (Figure 4) and a rose diagram (Figure 5) for use in interpretation of the clast fabric.

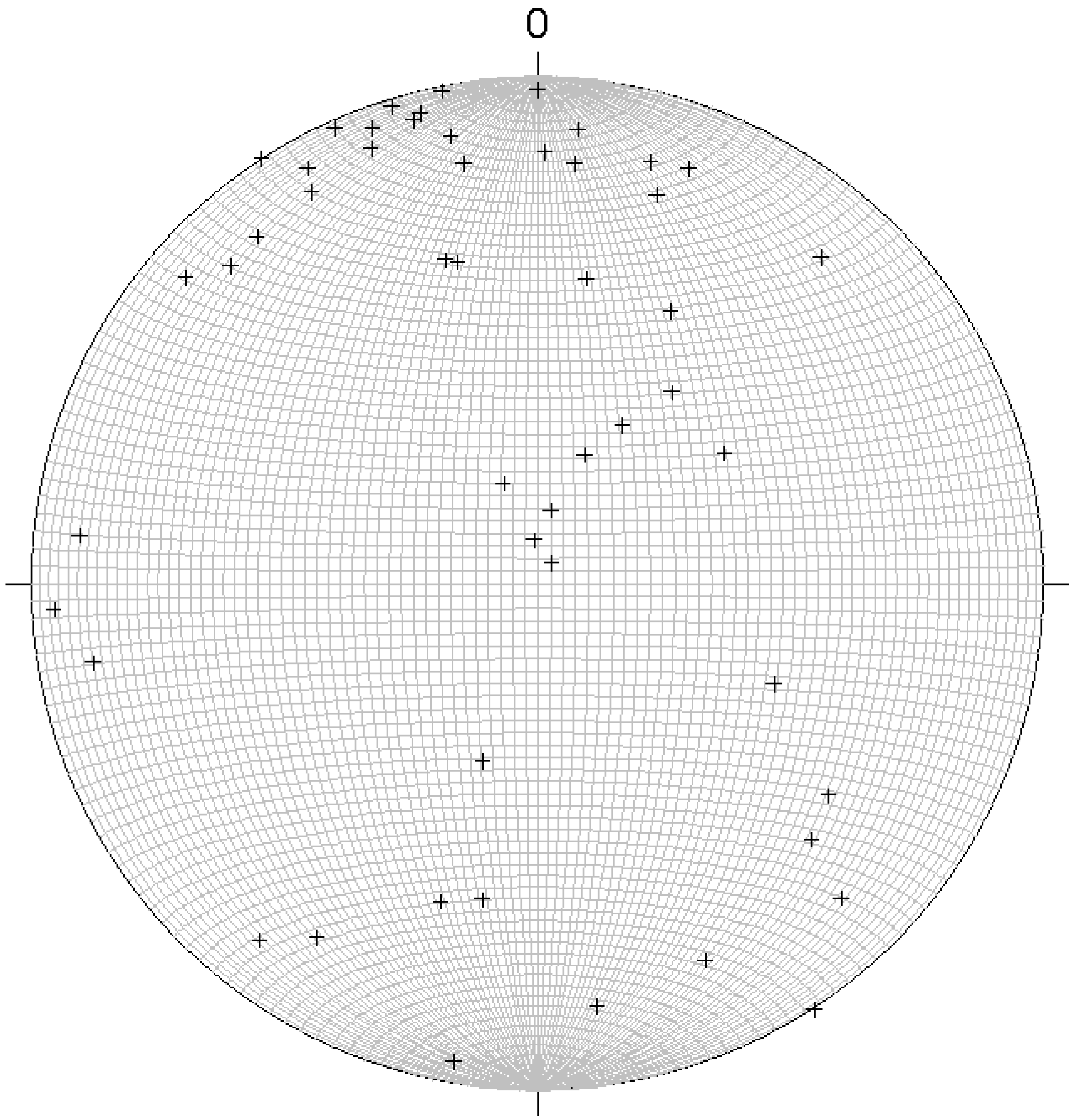

Figure 3 – An equal-area stereographic scatterplot of the clasts (n = 50).

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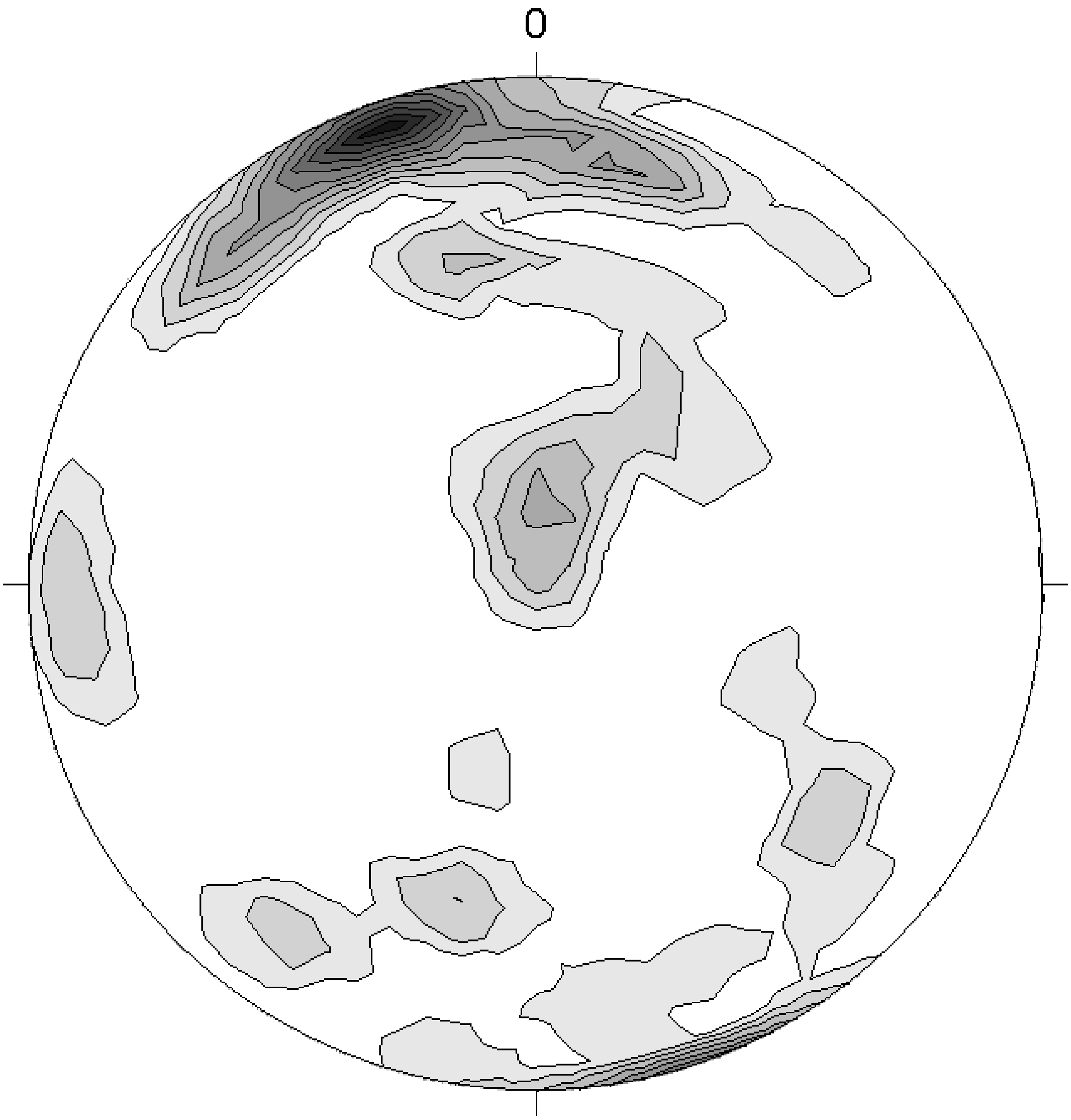

Figure 4 - An equal-area stereographic contour plot of the clasts (contour increments of 1.00)

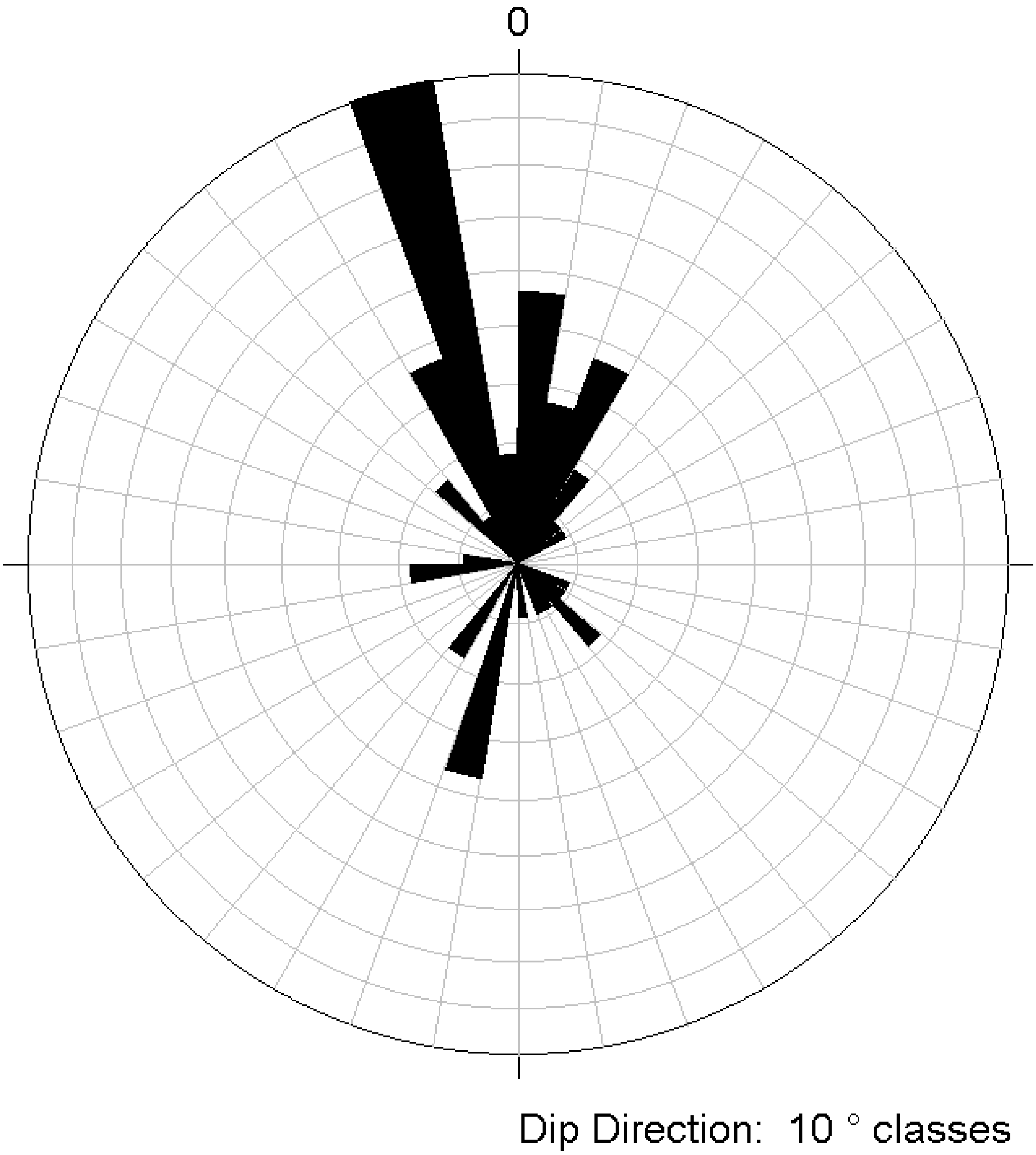

Figure 5 - A rose diagram of clast orientation (largest petal contains 9 clasts).

In the initial stages of our data collection we observed clast orientations that exhibited very little consistency. As we excavated further into the till, we began to see a pattern develop that was more consistent with the observations of clast fabrics in other studies. That is, the glacial till began to display a clast fabric that one might expect to find in this particular region in terms of the strain associated with a push moraine. Therefore, we feel it is reasonable to attribute the inconsistency of the data collected at the onset of this project to the fact that the till may have been disturbed, or could have been altered due to slumping. In addition, when considering the accuracy of the compass bearing measurements, we must also take into consideration human error. This could account for a margin of error in the range of 5 to 10 degrees for some measurements.

Based on research done by Tzakas et al. (2002) we would expect the elongate portion of the clast to be oriented in a direction slightly west of north (or east of south). The data we collected seems to be consistent with this laboratory model, with the highest frequency of clast orientation falling near this compass direction. In this case we found that the clasts were generally oriented in a north-south direction, with the highest frequency occurring between 340 degrees and 350 degrees.

Further interpretation of the clast fabric data, in order to determine till genesis, can be done using eigenvector analysis. This procedure is a computer-based statistical type of analysis, which determines the mean orientation and scatter of clasts about that mean. The preferred long axis eigenvector (V1) was calculated to be in the direction (350.8^{O}, 12^{O}), the intermediate eigenvector (V2) was calculated to be in the direction (101.8^{O}, 59.3^{O}) and the minimum eigenvector (V3) was calculated to be in the direction (254.3^{O}, 27.8^{O}). Eigenvalues give an indication of fabric strength, so a strong fabric would have a high value in the direction of preferred long axis orientation (S1) and a small value in the direction of minimum orientation (S3). The calculated eigenvalues for our data indicate a relatively weak fabric, with a value of 0.593 for eigenvalue S1 and a value of 0.164 for eigenvalue S3. Therefore, based on our observed eigenvalues and the till classification scheme developed by Dowdeswell et al. (1985), the till at our location can most likely be called a flow till. However, this type of till analysis and interpretation is not accepted by everyone, since it does not take into account localized factors that may have contributed to the clast fabric.

Clast direction is widely considered to be in alignment with the direction of the finite stress vectors in glacial push moraine deposits. While our data appears to be consistent with the model data, further excavation along the moraine is needed in order to interpret if this data is anomalous, or if it is indeed the result of strain caused by a moving glacial lobe. Perhaps excavation in the area of Port Jefferson could provide significant insight into the expected discrepancies of clast orientation from that of Stony Brook as a result of the curvature of the moraine as indicated in figure 6.

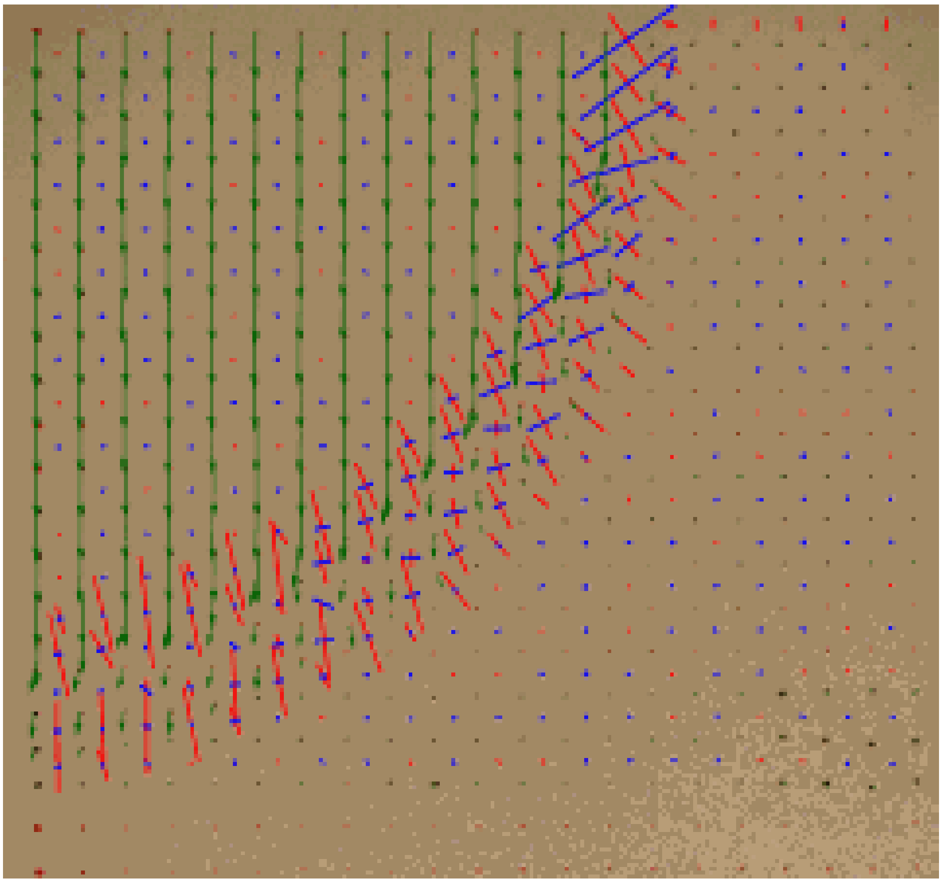

Figure 6 – Displacement vectors (green) and the horizontal components of compressional and extensional axes (red and blue, respectively). (Tzakas et al., 2002)

References

Dowdeswell, J.A., Hambry, M.J. and Wu, R. 1985. A comparison of clast fabric and shape in Late Precambrian and modern glacigenic sediments. *Journal of Sedimentary Petrology* 55: 691-704.

Klein, E. and Davis, D. 2002. Surface Sample Bias and Clast Fabric Interpretation Based on Till, Ditch Plains, Long Island, April 2002, Long Island Geologists, State University of New York. http://www.geo.sunysb.edu/lig/Conferences/abstracts_02/klein/klein.htm

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Appendix

Table 1 – Summary of the bearing and plunge of the elongated axis of each clast.

Clast Number	Bearing (in degrees)	Plunge (in degrees)
1	260	12

2	147	0
3	20	68
4	55	53
5	113	48
6	126	30
7	41	16
8	190	5
9	346	5
10	341	73
11	34	86
12	133	27
13	321	13
14	10	78
15	197	35
16	197	60
17	276	10
18	355	83
19	346	35
20	267	10
21	28	61
22	9	39
23	5	11
24	172	17
25	156	20
26	340	5
27	136	15
28	1	16
29	5	18
30	218	12
31	350	17
32	330	12
33	311	9
34	316	14
35	345	6
36	336	2
37	343	2
38	0	3
39	212	19
40	35	52
41	15	15
42	349	1
43	344	34
44	20	14
45	339	9
46	190	37

47	17	21
48	331	7
49	26	40
50	349	11