DSwr

DSgm

Dbg

DSwr

A

A'

MARSHFIELD

PEACHAM

GROTON STATE FOREST

PLAINFIELD

GROTON

STATE FOREST

CABOT

Magnetic declination 16 degrees west, 1986

0 0.5 1 2 Miles

0 0.5 1 2 3 4 5 Kilometers

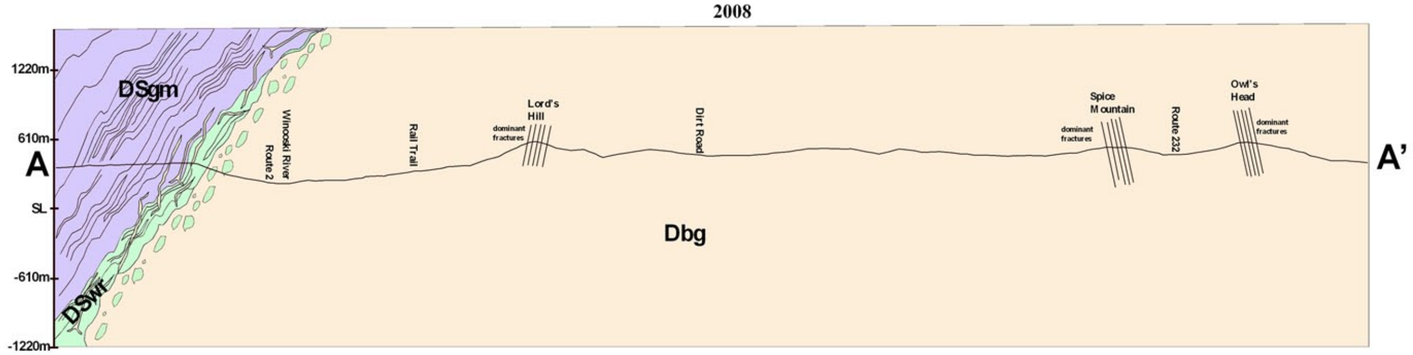
1:24,000

Field Area Location

Bedrock Geologic Map of the Knox Mountains Pluton Area: Marshfield and Peacham, Vermont

Authors: Jonathan Kim, Robert Charnock, Daniel Chow, and George Springston

2008



Description of Map Units

Cretaceous

K Dark gray biotite and amphibole phyric lamprophyre dike

Devonian

Dkmg Knox Mountain Granite of the New Hampshire Series; Massive medium-grained black and white speckled, quartz, K-feldspar, plagioclase, biotite +/- garnet granite; intruded into Dgm and Dgmc; the dominant lithology in the Knox Mountain Pluton is intermediate between biotite-poor and biotite-rich varieties; within a single outcrop, the granite may vary from biotite-rich to biotite-poor and from K-feldspar porphyritic to non-porphyritic; fine-grained muscovite occurs locally. Dikes of biotite-poor granite and multiple generations of pegmatite (quartz, K-feldspar, biotite,muscovite) are common.

Dgg Massive medium-grained gray K-feldspar porphyritic granite; intruded into Dgm and Dgmc; composed of quartz, K-feldspar, and plagioclase; color is darker and matrix is finer grained than Dkmg.

Silurian and Devonian

Gile Mountain Formation

DSgm Rusty-weathering, non-calcareous gray to black, locally graphitic, biotite, muscovite, quartz, garnet, +/- staurolite phyllite with conspicuous biotite porphyroblasts that grew within and across the dominant foliation; interlayed with gray non-calcareous phyllitic biotite quartzites and massive gray granular quartzites; isolated layers of massive gray to punky brown dirty marbles and calcareous quartzites occur locally ; rare garnet amphibolite horizons occur between calcareous and non-calcareous units.

Waits River Formation

DSwr Rusty-weathering, dominantly calcareous, gray to black, locally graphitic, biotite, muscovite, quartz, garnet, +/- staurolite phyllite with conspicuous biotite porphyroblasts that grew within and across the dominant foliation; interlayed with massive gray to punky brown dirty marbles and calcareous quartzites, and gray calcareous phyllitic biotite quartzites, massive non-calcareous gray granular quartzites occur infrequently ; rare garnet amphibolite horizons occur between calcareous and non-calcareous units.

Explanation of Map Zones

Zones of abundant granite sills and dikes

Zones of abundant xenoliths of the Dgm and Dgmc country rock in Dkmg

Outcrop Locations

- Field Stations (outcrops) from this study
- Selected outdrops from Konig (1961)
- Large Outcrops (this study)

Structural Symbols

30 strike and dip of dominant foliation

trend and plunge of lineation

25

References:
Konig, R.H, 1961, Geology of the Plainfield Quadrangle, Vermont: Vermont Geological Survey Bulletin #16, 86 p.

Base maps from USGS Topographic Quadrangles
Coordinate System: Vermont State Plane, meters, NAD 27
UTM coordinates shown on map border are NAD 83
Contour interval 6 meters/20 feet

Digital Cartography by Jonathan Kim
Vermont Geological Survey

This map is not a survey and is for planning purposes only
September 29, 2008

Research supported by the Vermont Geological Survey, Dept. of Environmental Conservation, VT ANR. This geologic map was funded in part by the USGS National Cooperative Mapping Program. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

Map Published By
Vermont Geological Survey
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Relative Igneous Chronology

1. Xenolith of Gile Mt schist (purple) and quartzite (green) altered to a calcsilicate hornfels.

2. Biotite-rich granite xenoliths within biotite-intermediate granite host. The biotite-rich phase is consistently the oldest.

3a. Biotite-intermediate granite is the most abundant granite type in the field area.

3b. K-feldspar porphyritic granite is roughly coeval with 3a. Both can be found within the same outcrop with no discernable contact relationship. Note biotite-rich enclave/xenolith.

4. Biotite-poor granite dikes that frequently have pegmatitic margins intruded the combined 3a and 3b.

5. Up to 3 generations of pegmatites crosscut events 1 - 4. For pegmatite orientations across the field area see Plate 3.

Relative Structural Chronology

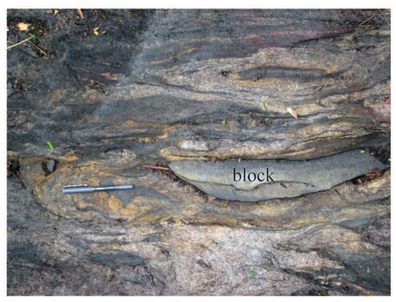
1. Whereas the interlayering of garnet-staurolite schists and quartzites appears to be bedding, pervasive intrafolial isoclinal folding (following plates) makes this unlikely.

2a. Acadian (Devonian) intrafolial F1 isocline in calcareous phyllitic quartzites of Gile Mt. Formation.

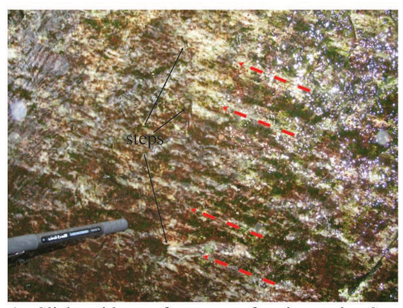
2b. F1 intrafolial isoclinal fold in calcareous phyllitic quartzite of the Gile Mt. Formation. The intersection of the F1 fold axis (see pen) with the S1 cleavage is a moderately to steeply-plunging stretching lineation.

2c. 2 lineations on the S1 surface of calcareous phyllitc quartzites. L1 is the stretching lineation associated with the F1 fold axis whereas L2 is a crenulation lineation colinear with Acadian F2 folds.

3a. Granite dike that clearly crosscuts S1 in the calcareous schists is folded by tight to isoclinal F2 folds; this constrains the dike to be post F1, but pre- F2.



3b. Isoclinally-folded (F2) granite dikes within Gile Mt. Formation schist near main granite contact; these folded dikes crosscut S1. Note rigid block of Gile Mt. Formation schist aligned with shallowly-plunging F2 fold axis.



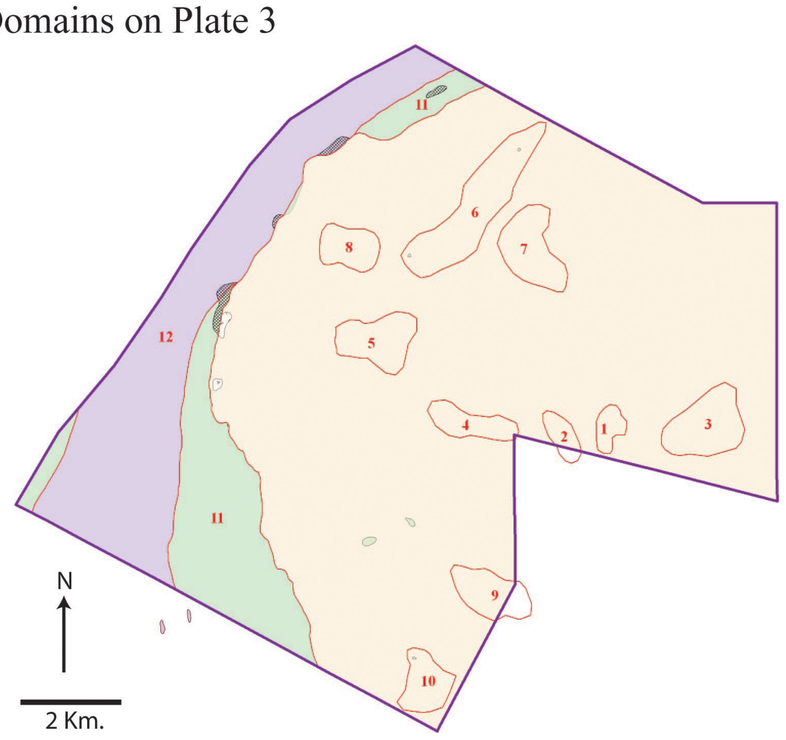
4a. Slickensides on fracture surface in granite. Steps indicate lower-right to upper-left kinematics. The age of these structures is uncertain.

4b. Looking along strike at northeast-trending vertical fracture zone at the contact between the Gile Mt.Formation metasedimentary rocks and the Knox Mountain Granite. Slickensides on these fracture planes indicate that the latest motion was right lateral.

Index Map for Fracture Domains on Plate 3

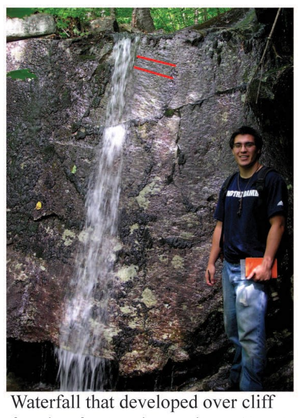
Cliff forming fractures in granite on Marshfield Mountain

Intersection of orthogonal vertical fracture sets with shallowly-dipping exfoliation fractures results in the detachment of “Leggo” blocks of granite on Marshfield Mountain.



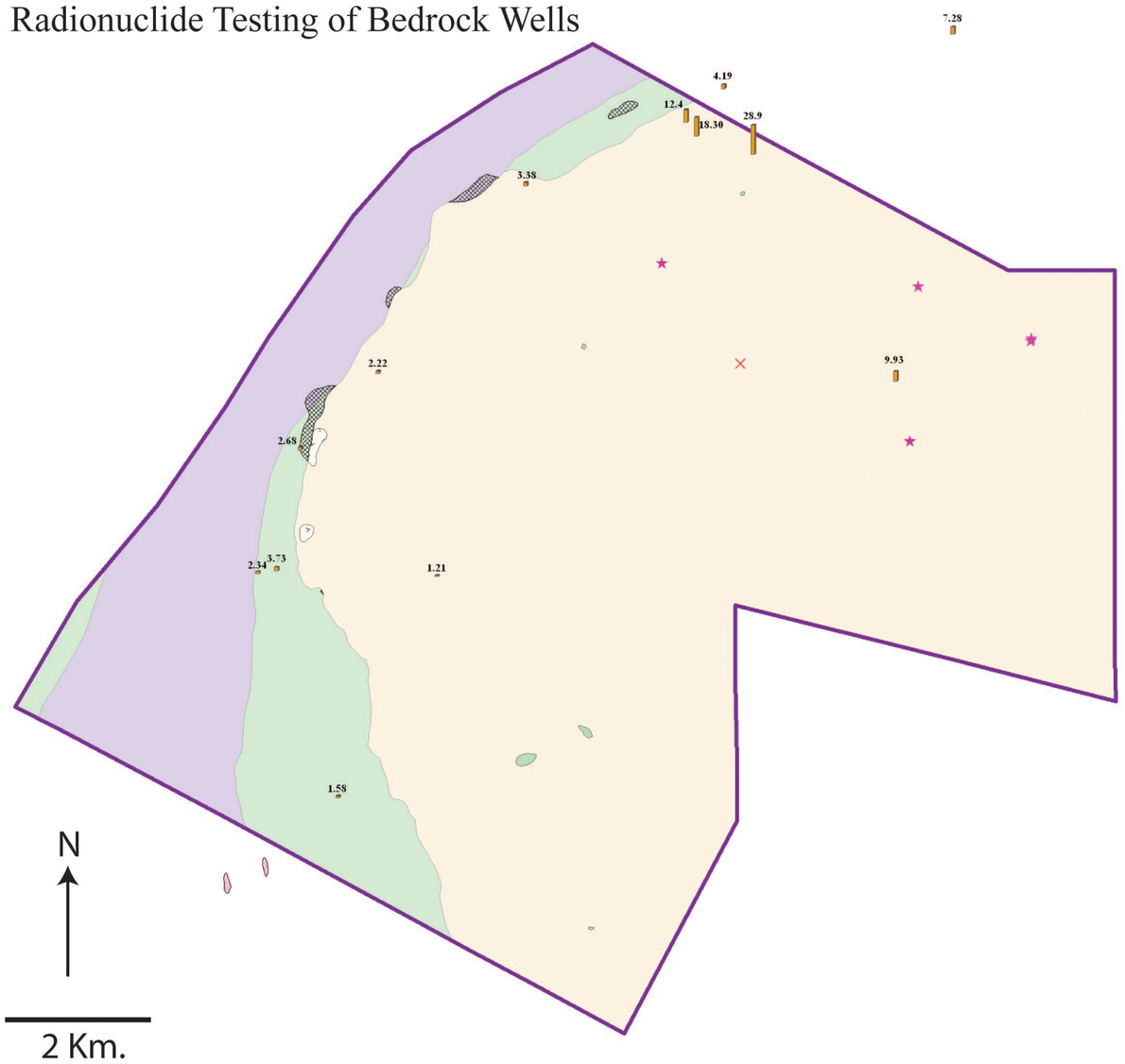
Closeup view of “Leggo” blocks of granite.

Anisotropy from pegmatite dikes promotes fracture formation in granite on Little Deer Mountain.



Waterfall that developed over cliff forming fracture in granite on Burnt Mountain. Note slickensides parallel to red lines.

Radionuclide Testing of Bedrock Wells



Magenta stars show the locations of bedrock wells that had elevated naturally-occurring radionuclide levels prior to the start of this mapping project; all of these wells had elevated Gross Alpha (the primary screening test) and some had elevated uranium. This project was initiated to address whether the elevated radionuclide levels were associated with specific igneous units within the granite. Gleason (2006) tested the radionuclide and major and trace element geochemistry of groundwater from 12 wells in the field area and 19 within the general area. Two of the 19 wells tested had Gross Alpha levels (see orange columns and associated numbers in picocuries/liter) that exceeded 15 picocuries/liter (Vermont Maximum Contaminant Level (MCL)) whereas 3 wells exceeded the MCL for uranium (200 parts per billion (ppb)). Gleason (2006) analyzed both granite and pegmatite samples and found that not only did the pegmatites have higher levels of uranium than the granites, but also this uranium was liberated more readily during short-term leaching tests. We were not able to delineate any map-scale igneous units in the granite and found that the complete relative igneous chronology shown above could be observed in individual outcrops.

Frequency-Azimuth Rose Diagrams and Equal Area Nets for Fracture Domains in the Knox Mountain Pluton Field Area

Granites

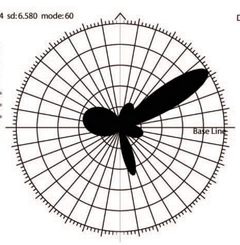
Domain 1- Owl's Head and Trails Fractures

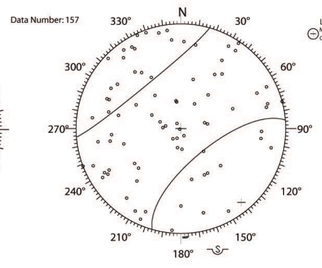
Frequency Gaussians
Total Data:157 max:15 min:0 mean:41.544 sd:6.580 mode:60

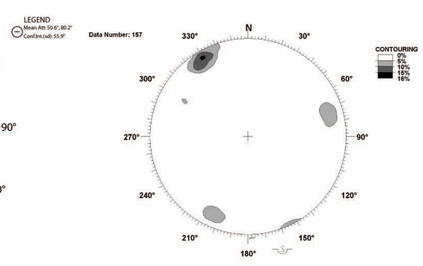
RMS = 0.2165224

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	26.57	100.00	6.211	57.10°	8.95°
2	11.14	46.49	2.887	164.3°	8.06°
3	31.19	35.79	2.223	287.2°	29.29°
4	12.79	23.94	1.487	24.23°	17.96°
5	12.14	21.00	1.304	105.9°	19.44°

Base Fit Value = 0.1199981







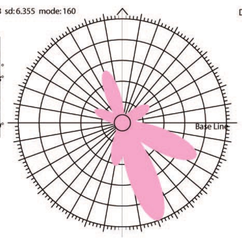
Domain 1- Owl's Head and Trails Pegmatites

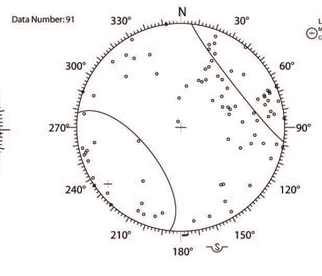
Frequency Gaussians
Total Data:91 max:7 min:0 mean:143.288 sd:6.355 mode:160

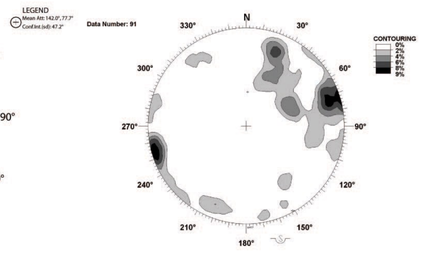
RMS = 0.136167

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	23.53	100.00	2.847	159.2°	10.0°
2	18.72	75.93	2.161	114.5°	10.48°
3	10.49	48.51	1.381	341.3°	9.2°
4	8.522	36.81	1.048	189.5°	9.85°
5	5.342	22.80	0.6491	294.2°	9.96°
6	6.640	24.15	0.6875	57.87°	11.69°

Base Fit Value = 0.2399962







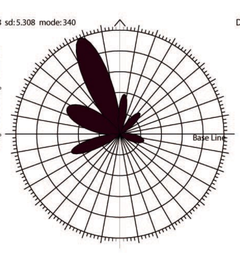
Domain 2- Spice Mountain Area Fractures

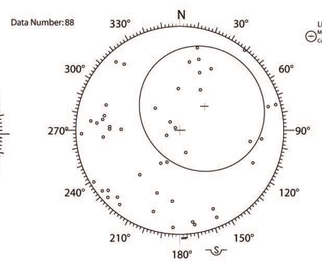
Frequency Gaussians
Total Data:88 max:20 min:0 mean:-35.238 sd:5.308 mode:340

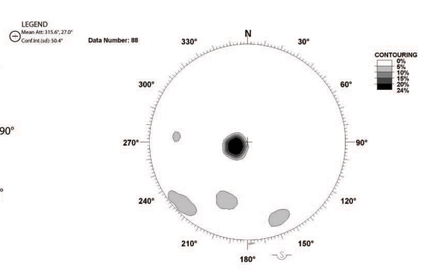
RMS = 0.1540736

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	30.75	100.00	3.780	337.5°	9.52°
2	24.78	56.52	2.136	296.3°	13.58°
3	13.28	49.72	1.880	249.5°	8.28°
4	9.340	38.59	1.459	6.522°	7.51°
5	8.192	27.68	1.046	43.56°	9.17°
6	9.232	23.90	0.9032	106.0°	11.96°

Base Fit Value = 0.001







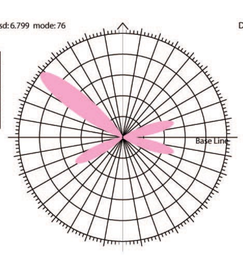
Domain 2- Spice Mountain Area Pegmatites

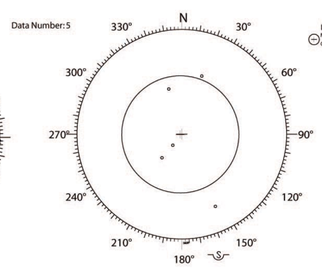
Frequency Gaussians
Total Data:5 max:1 min:0 mean:-34.168 sd:6.799 mode:76

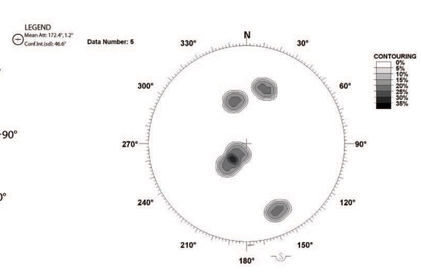
RMS = 6.50396E-03

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	41.10	100.00	0.3651	308.0°	7.5°
2	20.61	51.24	0.1871	242.0°	7.33°
3	20.40	50.82	0.1856	106.1°	7.32°
4	20.40	50.82	0.1856	73.86°	7.32°

Base Fit Value = 0.001







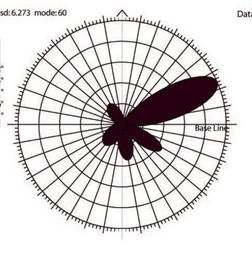
Domain 3- Big and Little Deer Mountains Fractures

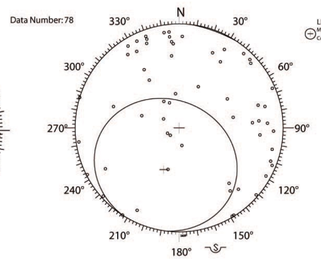
Frequency Gaussians
Total Data:78 max:8 min:0 mean:97.803 sd:6.273 mode:60

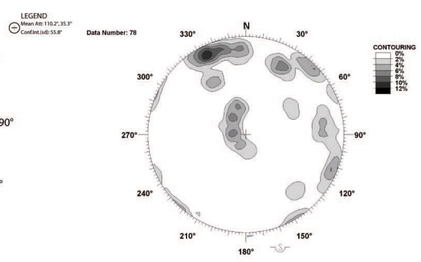
RMS = 0.1657067

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	33.38	100.00	2.905	65.88°	11.92°
2	13.03	41.74	1.212	122.9°	11.15°
3	12.35	31.03	0.9013	170.4°	14.21°
4	9.037	18.92	0.5494	327.0°	17.06°
5	11.67	21.57	0.6266	222.3°	19.31°

Base Fit Value = 0.1599976







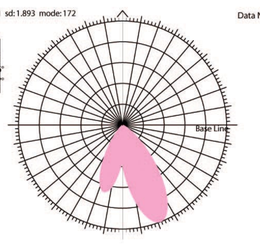
Domain 3- Big and Little Deer Mountains Pegmatites

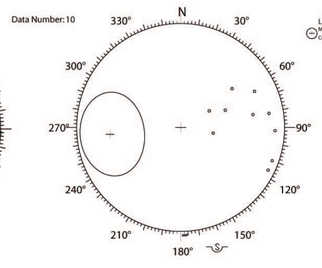
Frequency Gaussians
Total Data:10 max:2 min:0 mean:172.401 sd:1.893 mode:172

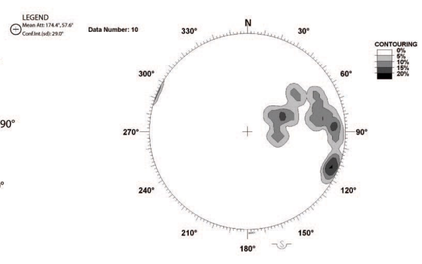
RMS = 1.657039E-02

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	66.71	100.00	0.6792	158.5°	13.06°
2	36.37	66.78	0.4536	195.5°	10.67°

Base Fit Value = 0.001







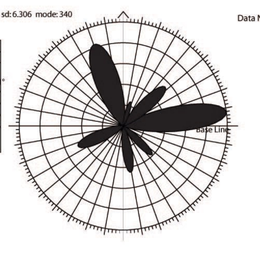
Domain 4- Kettle Mountain Area Fractures

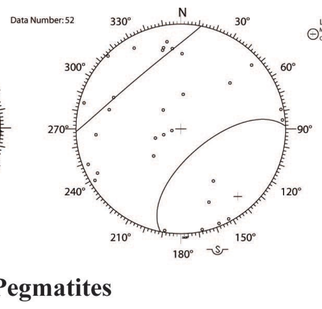
Frequency Gaussians
Total Data:52 max:5 min:0 mean:48.652 sd:6.306 mode:340

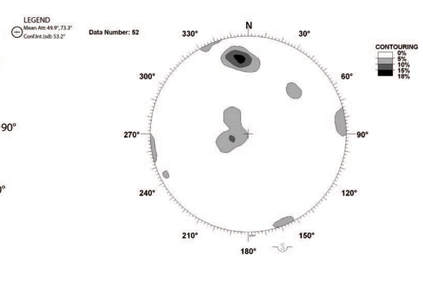
RMS = 5.241307E-02

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	26.41	100.00	1.883	82.34°	9.7°
2	25.60	83.21	1.567	340.5°	11.31°
3	12.42	47.62	0.8970	246.1°	9.58°
4	13.19	55.03	1.037	47.13°	8.81°
5	9.802	45.18	0.8510	171.0°	7.98°
6	7.741	39.14	0.7372	135.0°	7.27°
7	4.470	24.18	0.4554	16.77°	6.8°

Base Fit Value = 0.001







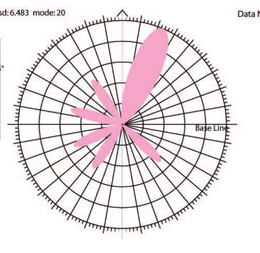
Domain 4- Kettle Mountain Area Pegmatites

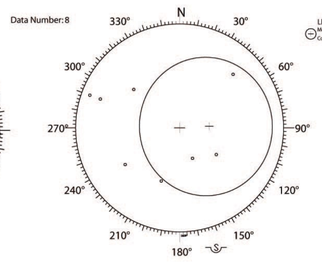
Frequency Gaussians
Total Data:8 max:2 min:0 mean:-27.346 sd:6.483 mode:20

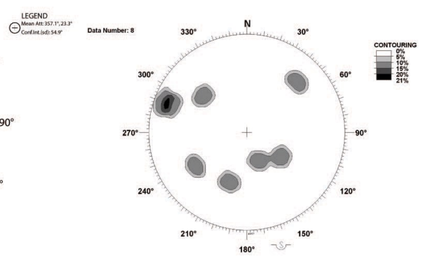
RMS = 1.577264E-02

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	38.45	100.00	0.3669	23.04°	11.15°
2	12.68	51.37	0.1885	286.0°	7.16°
3	12.80	50.53	0.1854	213.9°	7.35°
4	12.88	51.00	0.1871	134.0°	7.33°
5	12.60	51.60	0.1893	326.0°	7.08°
6	12.62	50.80	0.1864	246.1°	7.21°

Base Fit Value = 0.001







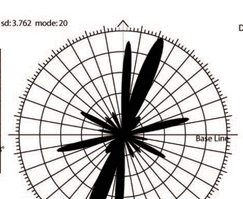
Domain 5- Lord's + Devil's Hills Fractures

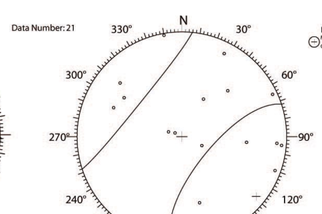
Frequency Gaussians
Total Data:21 max:3 min:0 mean:25.303 sd:3.762 mode:20

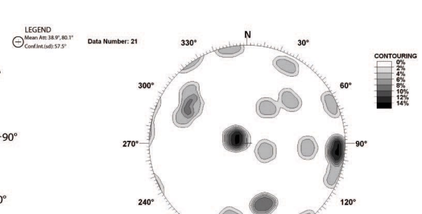
RMS = 2.903076E-02

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	32.12	100.00	0.7901	21.77°	5.68°
2	17.22	90.05	0.7115	3.432°	3.38°
3	14.05	65.05	0.5139	76.44°	3.82°
4	9.838	45.79	0.3618	-62.00°	3.8°
5	4.872	23.76	0.1877	-24.97°	3.63°
6	4.708	23.72	0.1874	-79.16°	3.52°
7	13.97	23.33	0.1843	43.62°	10.58°
8	4.686	23.76	0.1877	-44.86°	3.5°

Base Fit Value = 0.001







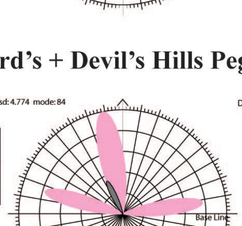
Domain 5- Lord's + Devil's Hills Pegmatites

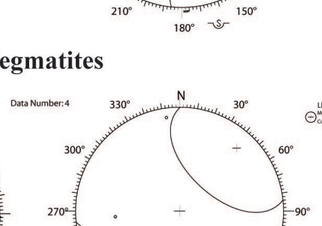
Frequency Gaussians
Total Data:4 max:1 min:0 mean:-10.103 sd:4.774 mode:84

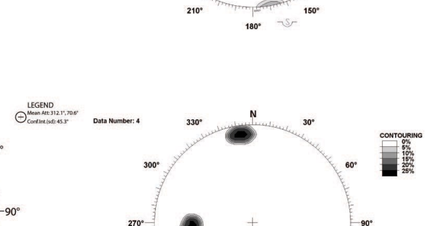
RMS = 6.826079E-03

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	41.67	100.00	0.2405	349.0°	9.22°
2	25.76	77.79	0.1871	82.00°	7.33°
3	25.74	77.84	0.1872	286.0°	7.32°
4	9.480	34.59	0.0832	334.1°	6.09°

Base Fit Value = 0.001







All plots made with Daisy3 version 4.65b software (Salvini, 2007)

Granites

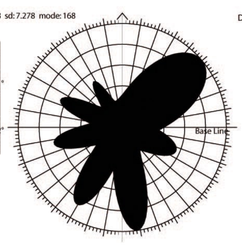
Domain 6- Drew Mountain Fractures

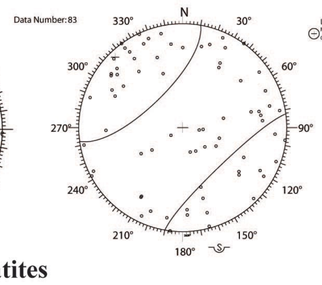
Frequency Gaussians
Total Data:83 max:5 min:0 mean:127.123 sd:7.278 mode:168

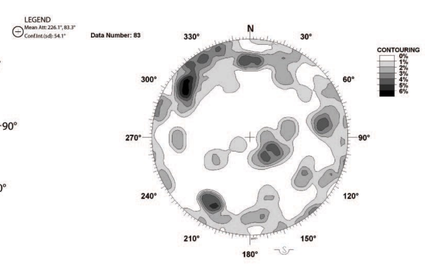
RMS = 5.989475E-02

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	10.85	99.80	1.225	171.9°	9.79°
2	20.91	100.00	1.227	49.53°	18.81°
3	8.606	81.05	0.9947	210.5°	9.55°
4	5.371	56.82	0.6974	256.9°	8.5°
5	4.417	53.74	0.6595	294.2°	7.41°
6	5.151	42.06	0.5162	113.8°	11.02°
7	2.239	36.40	0.4467	328.3°	5.56°

Base Fit Value = 0.3999937







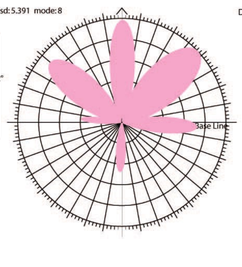
Domain 6- Drew Mountain Pegmatites

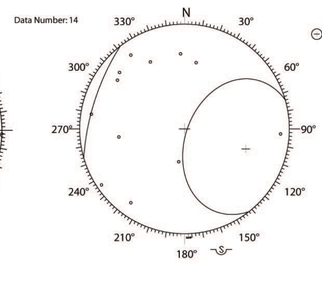
Frequency Gaussians
Total Data:14 max:2 min:0 mean:16.018 sd:5.391 mode:8

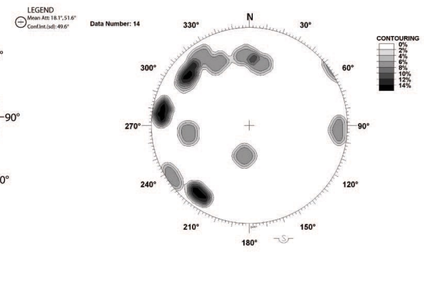
RMS = 1.892615E-02

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	19.71	98.27	0.3867	0.4298°	9.49°
2	24.49	89.66	0.3528	309.9°	12.92°
3	32.35	100.00	0.3935	46.95°	15.3°
4	12.64	72.19	0.2841	93.53°	8.3°
5	7.360	47.55	0.1871	182.0°	7.33°
6	4.593	39.27	0.1545	274.9°	5.57°

Base Fit Value = 0.001







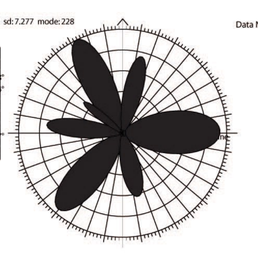
Domain 7- Marshfield + Burnt Mountains Fractures

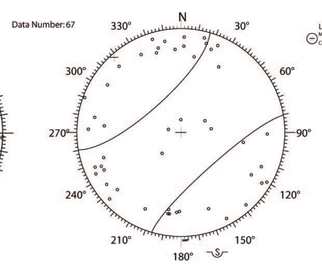
Frequency Gaussians
Total Data:67 max:6 min:0 mean:-39.487 sd:7.277 mode:228

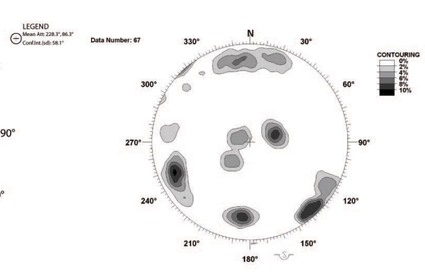
RMS = 5.777337E-02

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	17.46	100.00	1.344	333.7°	11.58°
2	18.66	95.64	1.285	220.4°	12.94°
3	24.52	93.45	1.256	89.02°	17.4°
4	10.14	72.61	0.9756	276.4°	9.27°
5	10.24	75.14	1.010	13.80°	9.03°
6	10.54	61.43	0.8254	166.5°	11.32°
7	4.226	46.34	0.6227	308.6°	6.08°

Base Fit Value = 0.0399994







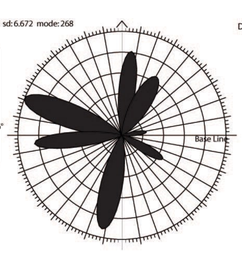
Domain 8- Loveland Ledges Area Fractures

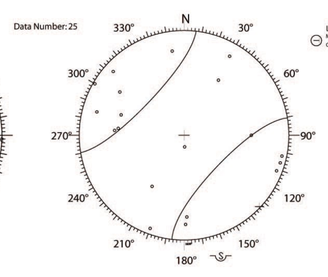
Frequency Gaussians
Total Data:25 max:4 min:0 mean:-52.773 sd:6.672 mode:268

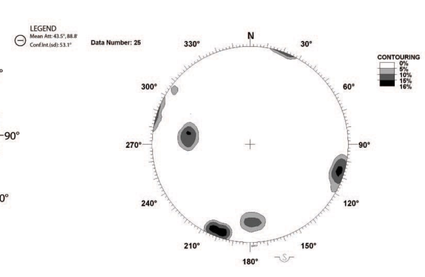
RMS = 0.0254493

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	22.62	100.00	0.8070	290.7°	9.33°
2	20.30	91.97	0.7422	191.7°	9.09°
3	15.30	81.22	0.6555	6.452°	7.77°
4	14.13	84.43	0.6813	264.8°	6.91°
5	17.36	65.26	0.5267	30.62°	10.96°
6	8.214	45.21	0.3648	120.0°	7.5°
7	3.874	23.71	0.1913	82.08°	6.74°

Base Fit Value = 0.001







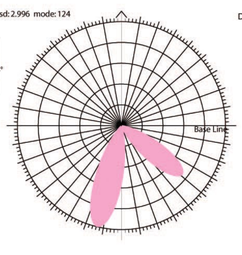
Domain 8- Loveland Ledges Area Pegmatites

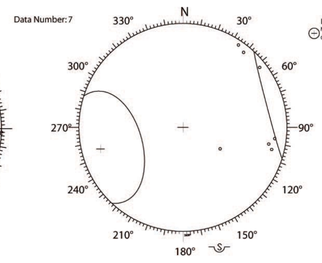
Frequency Gaussians
Total Data:7 max:1 min:0 mean:168.596 sd:2.996 mode:124

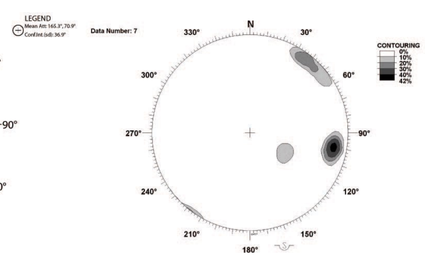
RMS = 1.822965E-02

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	57.83	100.00	0.5155	193.3°	10.44°
2	43.68	75.11	0.3872	128.8°	10.5°

Base Fit Value = 0.001







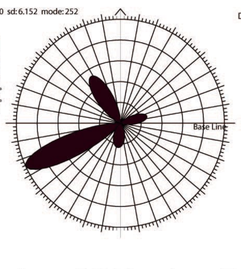
Domain 9- Hardwood Ridge Area Fractures

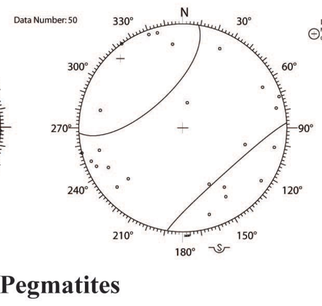
Frequency Gaussians
Total Data:50 max:11 min:0 mean:260.900 sd:6.152 mode:252

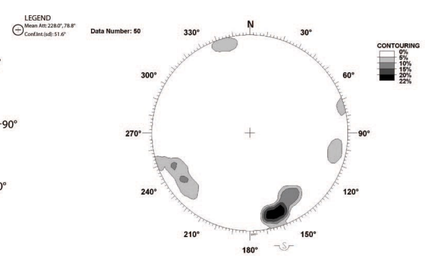
RMS = 0.1028569

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	38.25	100.00	2.872	245.4°	8.87°
2	27.29	53.08	1.524	328.0°	11.9°
3	18.73	23.50	0.6750	185.7°	18.44°
4	14.88	26.32	0.7560	75.37°	13.09°

Base Fit Value = 0.001







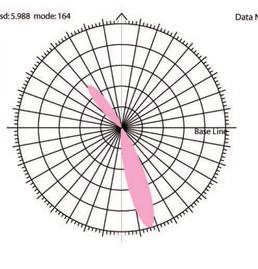
Domain 9- Hardwood Ridge Area Pegmatites

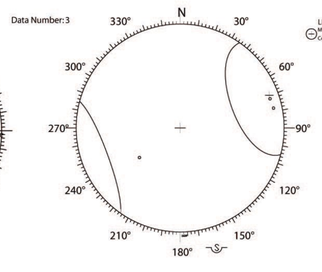
Frequency Gaussians
Total Data:3 max:1 min:0 mean:183.619 sd:5.988 mode:164

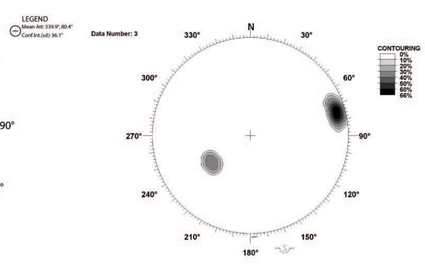
RMS = 5.13464E-03

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	68.50	100.00	0.3651	164.0°	7.5°
2	34.35	51.24	0.1871	322.0°	7.33°

Base Fit Value = 0.001







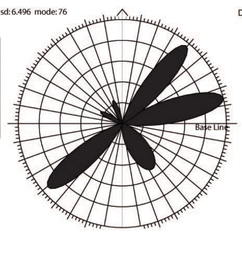
Domain 10- Pigeon Pond Area Fractures

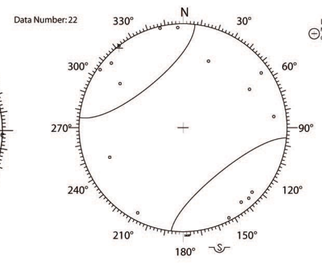
Frequency Gaussians
Total Data:22 max:4 min:0 mean:98.577 sd:6.496 mode:76

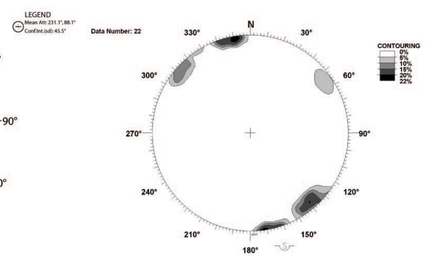
RMS = 4.060397E-02

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	25.00	100.00	0.7929	75.83°	9.23°
2	23.11	94.09	0.7460	229.4°	9.07°
3	21.78	96.77	0.7673	39.43°	8.31°
4	21.14	52.36	0.4151	146.5°	14.9°
5	4.644	23.69	0.1879	297.9°	7.24°
6	4.641	23.70	0.1879	338.1°	7.23°

Base Fit Value = 0.001







Metasedimentary Rocks

Domain 11- Gile Mountain Formation- Calcareous Member Fractures

Frequency Gaussians
Total Data:95 max:10 min:0 mean:81.581 sd:7.258 mode:128

RMS = 8.318464E-02

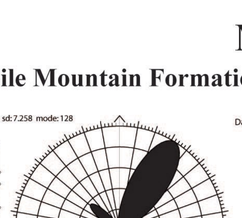
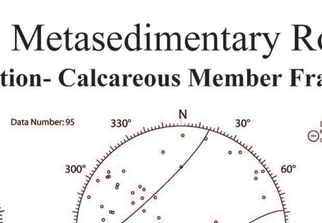
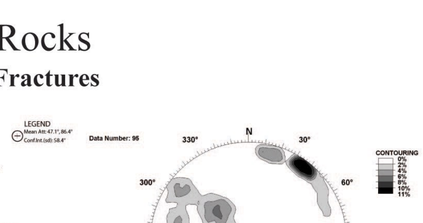
GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	28.87	100.00	2.700	31.93°	13.5°
2	15.16	69.08	1.865	126.9°	10.28°
3	11.53	74.15	2.002	271.0°	7.28°
4	10.35	47.61	1.285	218.6°	10.18°
5	6.121	33.45	0.9031	311.5°	8.56°
6	9.174	32.68	0.8824	184.1°	13.14°
7	4.526	30.07	0.8118	96.13°	7.07°

Base Fit Value = 0.1599977

Domain 12- Gile Mt Formation- Non-Calcareous Member Fractures

Frequency Gaussians
Total Data:76 max:9 min:0 mean:-32.816 sd:7.467 mode:96

RMS = 0.162979

GAUSSIAN PARAMETERS					
#	%	Nor.H.	Max H.	Azimuth	sd
1	37.15	100.00	2.964	89.04°	12.67°
2	27.98	82.63	2.450	281.5°	11.54°
3	11.92	42.92	1.272	319.0°	9.47°
4	13.22	24.76	0.7339	191.6°	18.2°
5	5.391	17.14	0.5081	224.7°	10.73°

Base Fit Value = 0.001