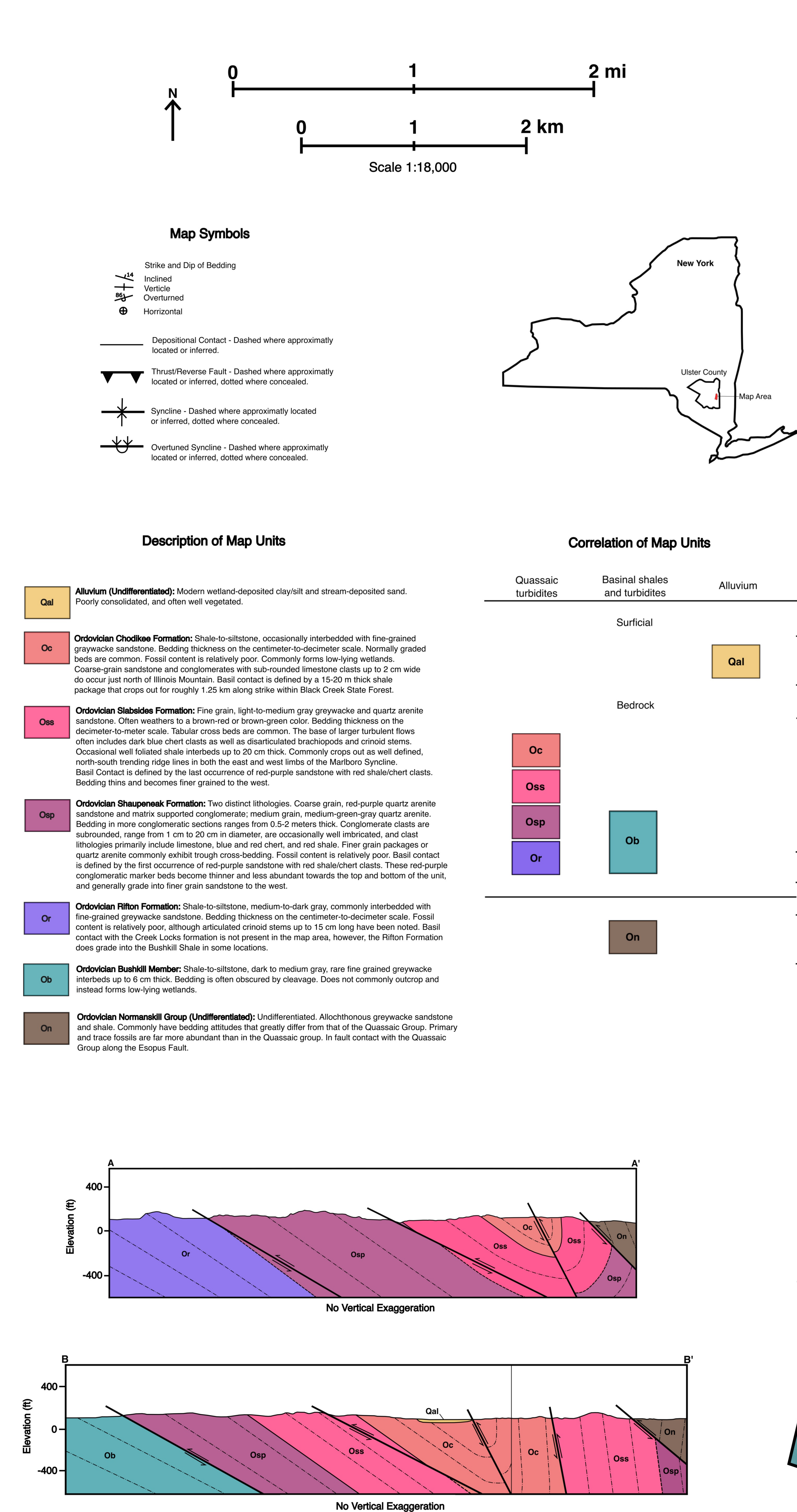# Structural Evolution of the Ordovician Quassaic Group, Marlboro Mountains, New York

Dylan Frawley[1], Myles Dower[2], Frederick Vollmer[2], Alex Bartholomew[2]

[1]Department of Geosciences, Colorado State University, 400 University Ave, Fort Collins, CO 80523
[2]Department of Geology, SUNY New Paltz, 47 S Manheim Blvd, New Paltz, NY 12561

GEOSCIENCES
COLORADO STATE UNIVERSITY

New Paltz
STATE UNIVERSITY OF NEW YORK

Map Symbols

Strike and Dip of Bedding
Inclined
Vertical
Overturned
Horizontal

Depositional Contact - Dashed where approximately located or inferred.

Thrust/Reverse Fault - Dashed where approximately located or inferred, dotted where concealed.

Syncline - Dashed where approximately located or inferred, dotted where concealed.

Overturned Syncline - Dashed where approximately located or inferred, dotted where concealed.

New York

Ulster County

Map Area

Description of Map Units

Qal — Alluvium (Undifferentiated): Modern wetland-deposited clay/silt and stream-deposited sand. Poorly consolidated, and often well vegetated.

Oc — Ordovician Chodikee Formation: Shale-to-siltstone, occasionally interbedded with fine-grained greywacke sandstone. Bedding thickness on the centimeter-to-decimeter scale. Normally graded beds are common. Fossil content is relatively poor. Coarse-grain sandstone and conglomerates with sub-rounded limestone clasts up to 2 cm wide do occur just north of Illinois Mountain. Basil contact is defined by a 15-20 m thick shale package that crops out for roughly 1.25 km along strike within Black Creek State Forest.

Oss — Ordovician Slabsides Formation: Fine grain, light-to-medium gray greywacke and quartz arenite sandstone. Often weathers to a brown-red or brown-green color. Bedding thickness on the decimeter-to-meter scale. Tabular cross beds are common. The base of larger turbulent flows often includes dark blue chert clasts as well as disarticulated brachiopods and crinoid stems. Occasional well foliated shale interbeds up to 20 cm thick. Commonly crops out as well defined, north-south trending ridge lines in both the east and west limbs of the Marlboro Syncline. Basil Contact is defined by the last occurrence of red-purple sandstone with red shale/chert clasts. Bedding thins and becomes finer grained to the west.

Osp — Ordovician Shaupeneak Formation: Two distinct lithologies. Coarse grain, red-purple quartz arenite sandstone and matrix supported conglomerate; medium grain, medium-green-gray quartz arenite. Bedding in more conglomeratic sections ranges from 0.5-2 meters thick. Conglomerate clasts are subrounded, range from 1 cm to 20 cm in diameter, are occasionally well imbricated, and clast lithologies primarily include limestone, blue and red chert, and red shale. Finer grain packages or quartz arenite commonly exhibit trough cross-bedding. Fossil content is relatively poor. Basil contact is defined by the first occurrence of red-purple sandstone with red shale/chert clasts. These red-purple conglomeratic marker beds become thinner and less abundant towards the top and bottom of the unit, and generally grade into finer grain sandstone to the west.

Or — Ordovician Rifton Formation: Shale-to-siltstone, medium-to-dark gray, commonly interbedded with fine-grained greywacke sandstone. Bedding thickness on the decimeter-to-meter scale. Fossil content is relatively poor, although articulated crinoid stems up to 15 cm long have been noted. Basil contact with the Creek Locks formation is not present in the map area, however, the Rifton Formation does grade into the Bushkill Shale in some locations.

Ob — Ordovician Bushkill Member: Shale-to-siltstone, dark to medium gray, rare fine grained greywacke interbeds up to 6 cm thick. Bedding is often obscured by cleavage. Does not commonly outcrop and instead forms low-lying wetlands.

On — Ordovician Normanskill Group (Undifferentiated): Undifferentiated. Allochthonous greywacke sandstone and shale. Commonly have bedding attitudes that greatly differ from that of the Quassaic Group. Primary and trace fossils are far more abundant than in the Quassaic group. In fault contact with the Quassaic Group along the Esopus Fault.

Correlation of Map Units

Quassaic turbidites	Basinal shales and turbidites	Alluvium	
		Surficial	
		Qal	Quaternary
		Bedrock	
Oc			Upper Ordovician
Oss			
Osp		Ob	Middle Ordovician
Or			
	Esopus Fault		
		On	Middle Ordovician

Scale 1:18,000

Background:

The Mid-to-Late Ordovician Quassaic Group is an autochthonous package of Taconic flysch phase turbidites in eastern Ulster County, NY. The Quassaic is preserved as an outlier in the core of the Marlboro Syncline, bound by the Esopus Thrust to the east, and grades into (or is thrust onto) the Bushkill shale to the west. Structures within the Quassaic record at least two contractional events. Reconnaissance 1:10,000 scale mapping was employed for a portion of the Marlboro Syncline. Additionally, more detailed geometric/kinematic structural analysis was performed in two geographically restricted domains (Fig.1). Domain analysis suggests the involvment of two contractional phases during the structural evolution of the Marlboro Mountains. Deformation associated with Taconic E-W shortening can be best seen in domain A, including the west-vergent folding of the Quassaic Group, and displacement of the Quassaic along the Esopus and Black Creek faults. Deformation associated with later Alleganian (?) N-S shortening is reflected in domain B as the re-folding of the Marlboro Syncline and axial planar cleavage and the formation of the Illinois Mountain Fault.
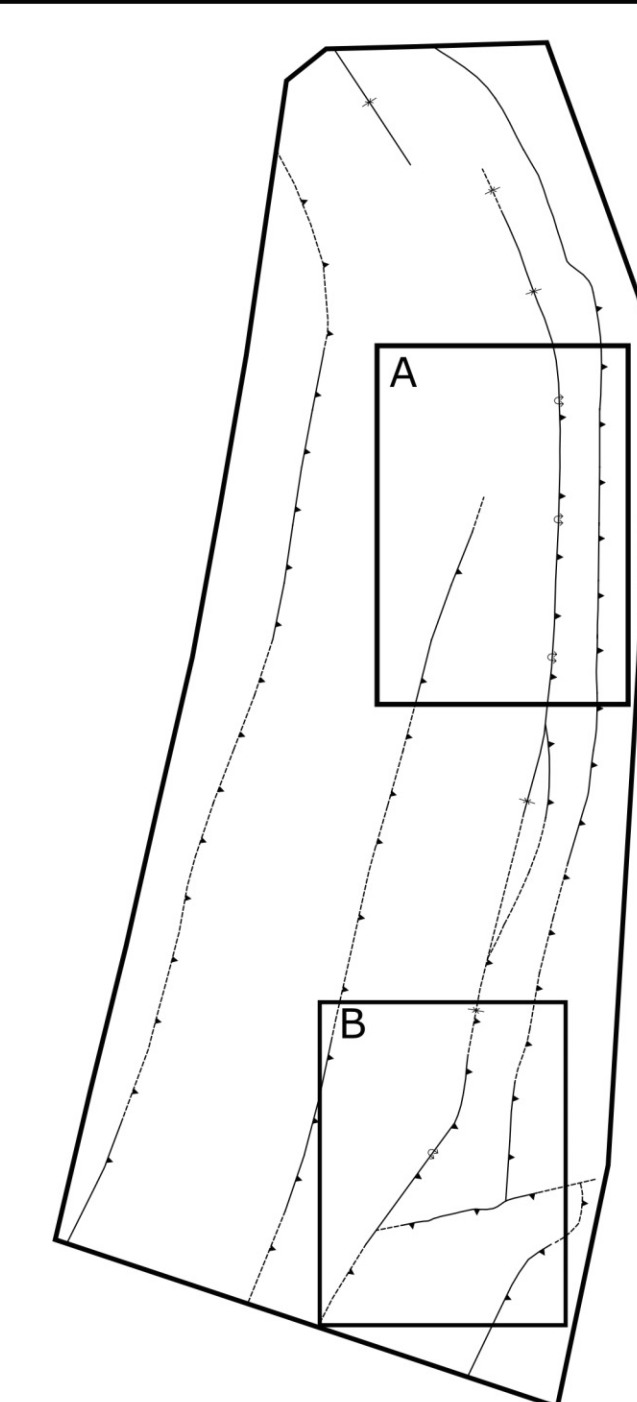
Fig. 1: Generalized map of major structures within the map area. Boxes show the geographic extent of structural domains A and B.

Structural Analysis Domain A:

Fig. 2: Syn-kinematic quartz veins associated with east-west shortening showing top-to-the-west displacement.

Fig. 4: Poles to bedding collected within domain A (Fig.1), defining the Marlboro Syncline. The fold axis is 169/18 (blue square). N = 200
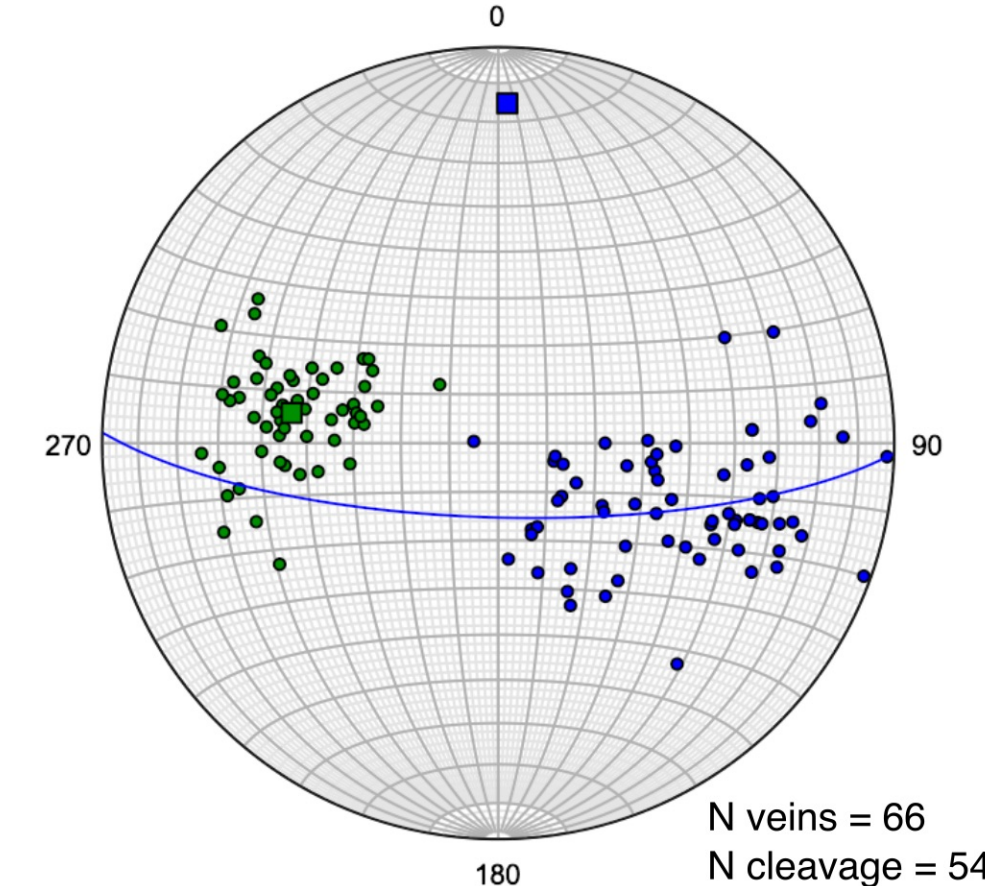
Fig. 3: Poles to syn-kinematic quartz veins (Fig.2) (blue) and poles to cleavage (green) collected within domain A (Fig.1). The minimum eigenvector to veins is 002/15 (blue square), representing the rotational axis associated with Taconic east-west shortening. The mean cleavage plane is 008/44 E (green square is the pole to this plane). N veins = 66, N cleavage = 54
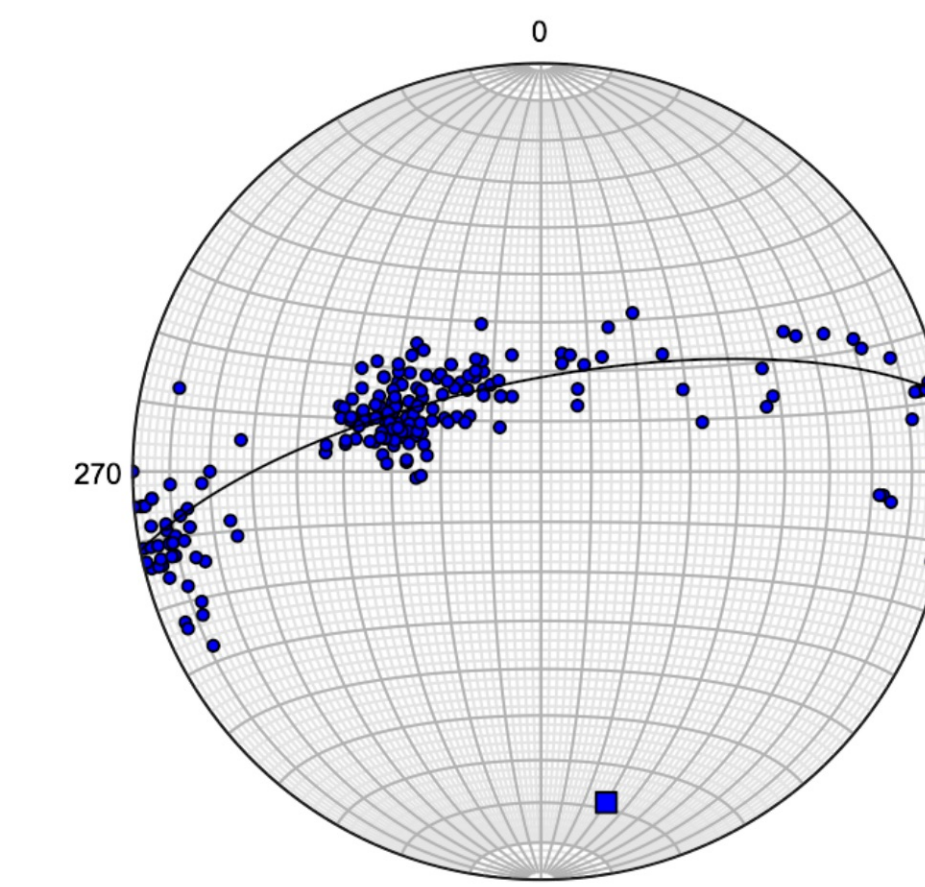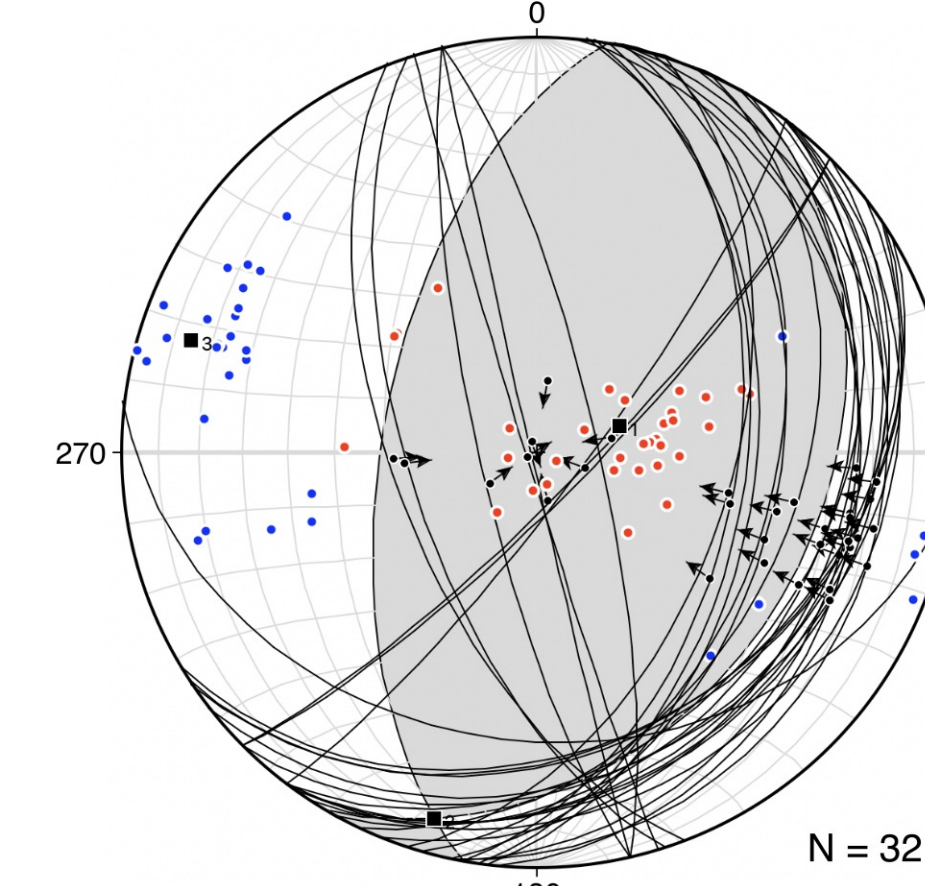
Fig. 5: Fault plane solution generated from small scale faults and flexural slip collected within domain A (Fig.1). P-axes are plotted in blue, T-axes are plotted in red, and arrows show hanging wall slip directions. The Linked Bingham shortening axis (point 3) is 288/14. N = 32
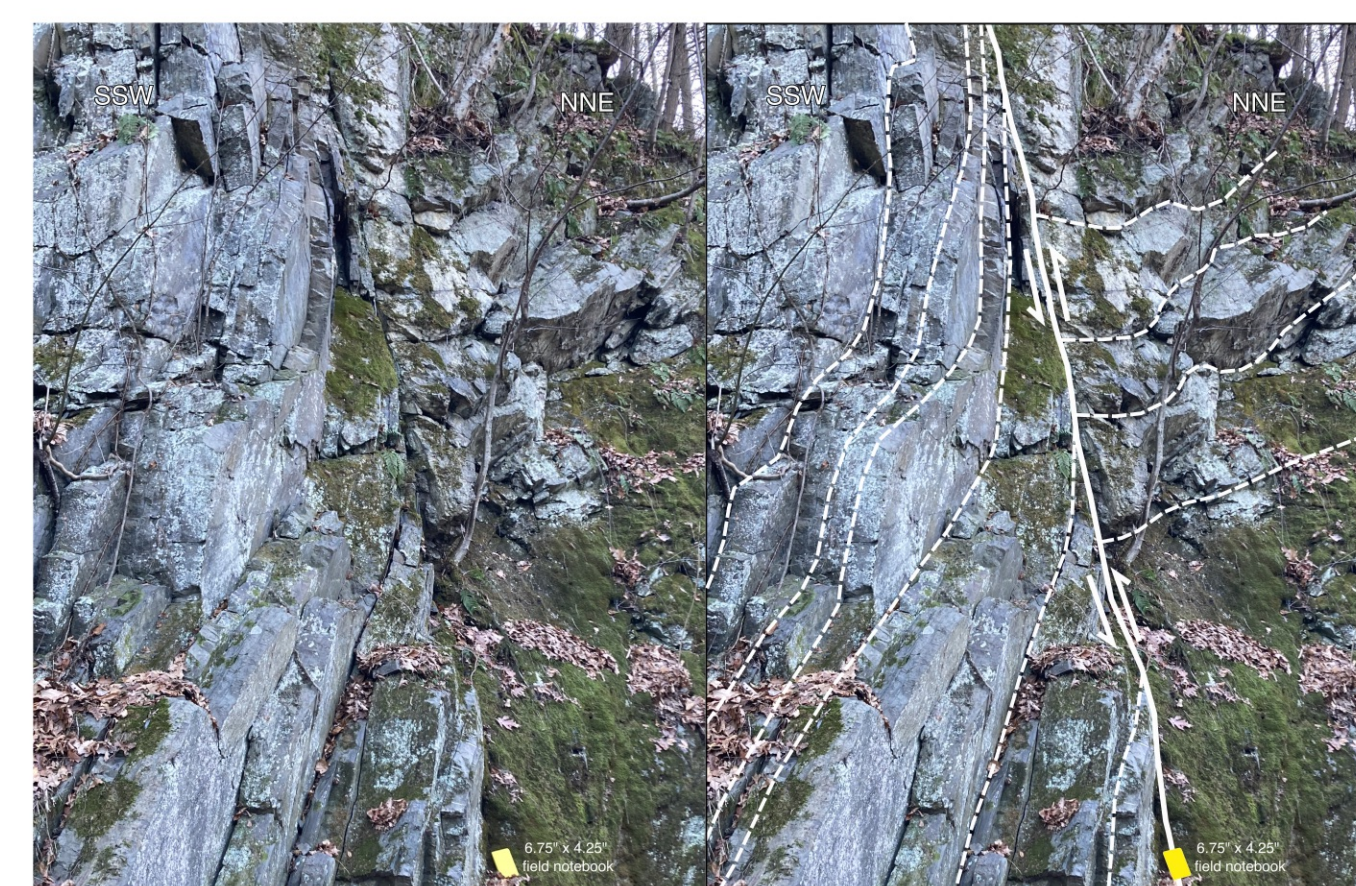
Structural Analysis Domain B:

Fig. 6: Outcrop scale high-angle reverse fault within the Illinois Mountain fault zone.

Fig. 8: Poles to bedding collected within domain B north of Route 299 (left) defining a fold axis of 190/00, and south of 299 (right) defining a fold axis of 046/13. N = 31, N = 41
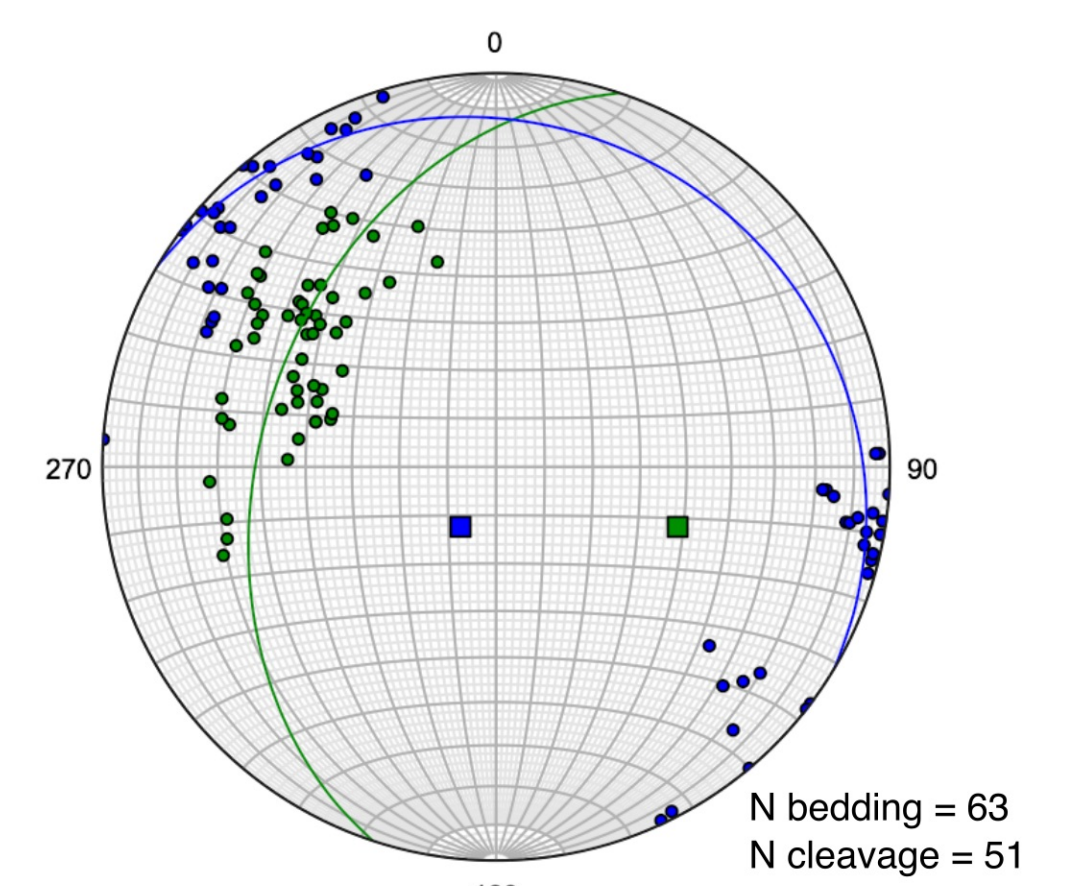
Fig. 7: Poles to bedding in the eastern limb of the Marlboro Syncline (blue) and poles to cleavage (green) collected within domain B (Fig.1). The minimum eigenvectors to bedding (211/76), and cleavage (108/50), are plotted as blue and green squares, respectively. N bedding = 63, N cleavage = 51
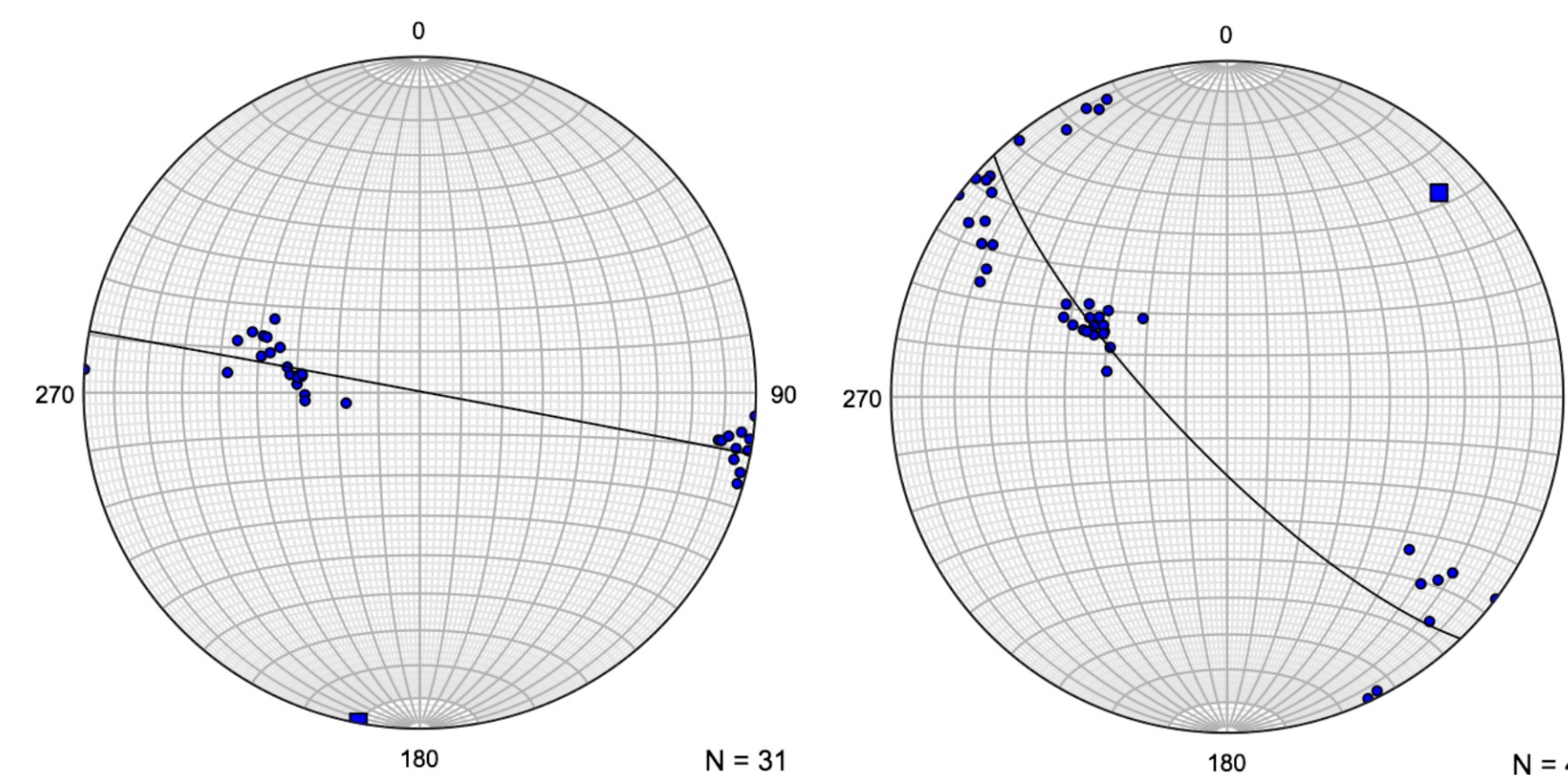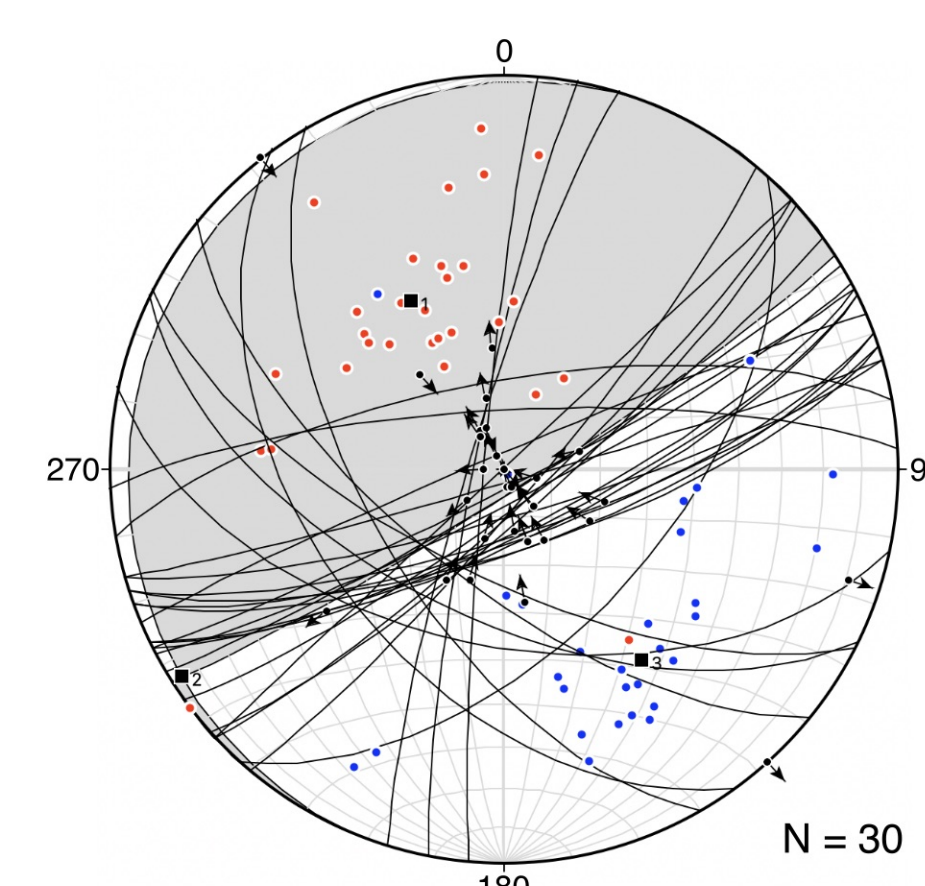
Fig. 9: Fault plane solution generated from small scale faults within the Illinois Mountain fault zone in domain B (Fig.1). P-axes are plotted in blue, T-axes are plotted in red, and arrows show hanging wall slip directions. The Linked Bingham shortening axis (point 3) is 144/40. N = 30