Primary and Secondary Structures in Archean Greenstone Belt

Aeron Vaillancourt and Christie Rowe
Earth and Planetary Sciences, McGill University, Montreal, Quebec, Canada

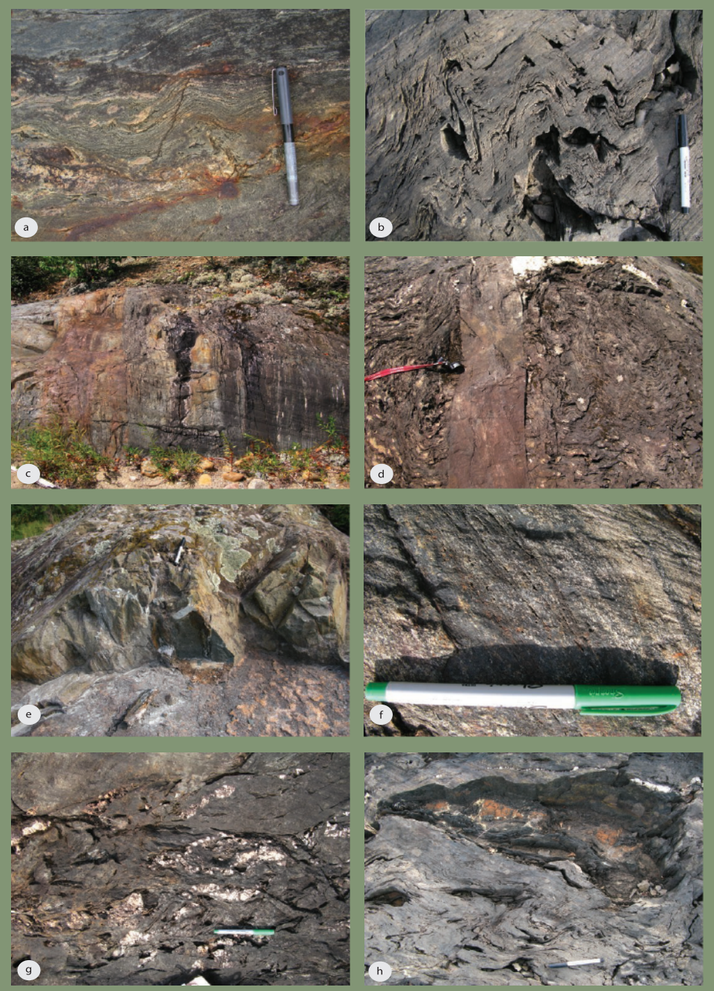
Abstract

Metabasaltic rocks comprise the majority of the Finlayson Lake Greenstone Belt, near Atikokan, Ontario. The research group is currently studying the lithostratigraphy and deformation history of this greenstone belt and the adjacent tonalite gneiss terrane, which are juxtaposed across the Marmion Shear zone. The Hammond Reef gold deposit is hosted in a fractured alteration zone which is potentially related to late motion on the Marmion Shear. The shear zone core is obscured by intrusion of post-kinematic granites. Therefore, we are pursuing structural studies of the deformed terranes which form the wall rock to the shear zone, as a basis for establishing the kinematic and metamorphic history of the region.

The highly deformed greenstone belt includes areas of chaotic, tightly folded metabasalt. If the folds are inherited from primary banding in the lavas, they might be used as stratigraphic markers to aid in mapping the structural history of the belt. If they are tectonic folds, they preserve a record of very high localized strains. This project includes field mapping and petrographic study of the folded units to determine the origin of the folded fabrics, and will determine whether they formed in a fluid state (primary) or by solid state deformation (tectonic), or represent a unique tectonized primary structure.

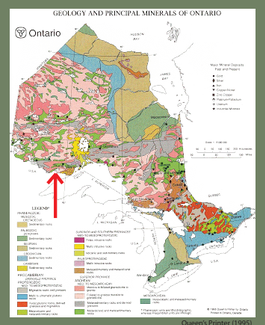
The results from this project will be used on a larger scale in coordination with work being done on the Finlayson side of the Marmion shear zone.

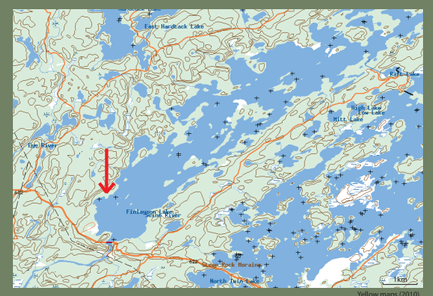
Finlayson outcrop images



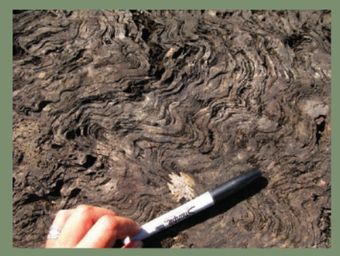
a) Folded thin laminations in the beach outcrop. b) Highly chaotic and disharmonic folding on the eastern limb of the outer layer of the fold. The lines visible on the surface of the outcrop are glacial striations. c) Contact between the fine-grained, highly lineated, chlorite rich unit and the coarse grained, pyrite rich, mafic unit. The coarse grained unit is possibly a dyke or an intrusion. d) A dyke crosscutting the hectic folding with a calcite vein at the top of the image. e) Nose of the center unit, another indication that the outcrop is folded on a large scale. f) Close up of the mineral lineation. g) Late calcite, quartz and albite veins. h) Highly weathered ankerite deposit.

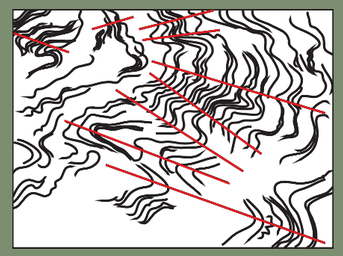
Study Site



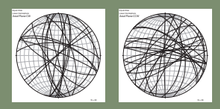


Chaotic Folding

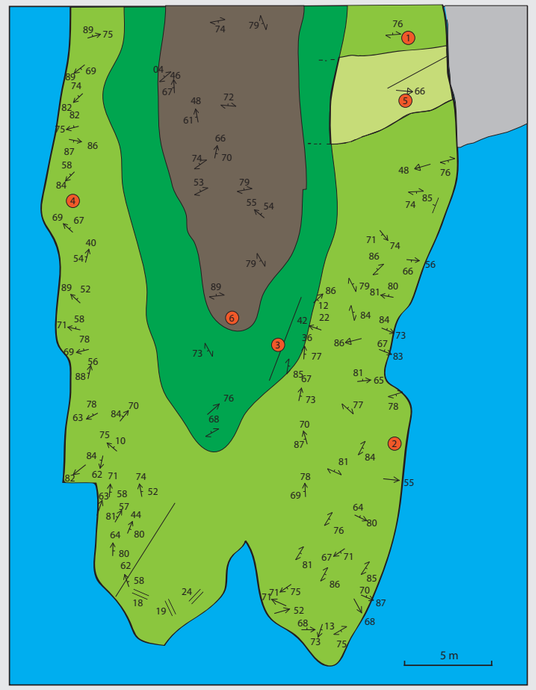




The axial planes of the large and small scale folds are discontinous over the study area. The hectic folding could be due to a low viscosity flow followed by later larger scale deformation. It is quite possible that this outcrop has undergone many different deformation events between the flow folding and later shear folding. The image above on the right is a outline of the folds in the image above to the left, it shows how varied the axial planes can be over a small scale. The stereonet to the right shows the axial planes for clockwise and counterclockwise folds over the entire outcrop.



Finlayson Field Data



Fine grained metabasalt, highly foliated, with mineral lineations.
Medium grained metabasalt, undulating foliation.
Fine to coarse grained, chaotically folded.
Coarse grained metabasalt, less alteration, highly foliatied, pyrite rich.

Foliation
Fold Hinge
Fold Hinge and Axial Surface
Mineral Lineation
Fracture Set
Sample
Dyke

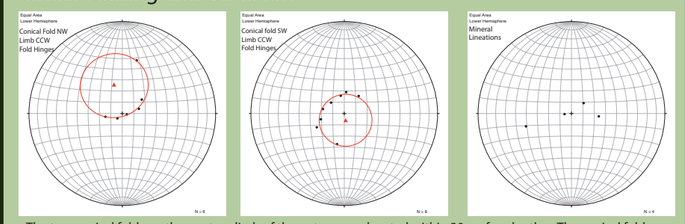
Thin Section and Petrographic Analysis

Dyke contact (sample 3)

Nose of a fold with cross cutting vein (sample 4)

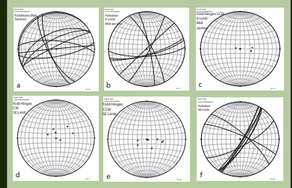
This suite of rocks is characterized by retrograde chlorite and sericite alteration. There is a pervasive sub-vertical mineral lineation and strong foliation in the majority of the samples studied. In a few localities there are some relic amphibole crystals that have either been partially or entirely replaced by other minerals, predominantly chlorite. Based on the mineralogy these samples are low-grade metamorphic rocks in the greenschist facies. These samples also have a large degree of late calcite, ankerite, albite and quartz veining.

Shear Folding and Direction



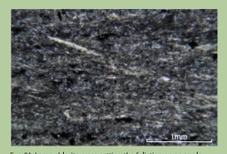
The two conical folds on the western limb of the outcrop are located within 20m of each other. The conical folds were found by spatially separating localized fold hinge data of counter-clock wise folds on the western limb. As data was plotted migrating northward along the western limb of the large scale fold it became apparent that the folds were rotating on small scales, although this is not the case with the entire data set of the western limb. These folds are possibly shear folds that could represent the same event that formed the mineral lineations shown in the 3rd stereonet.

Additional Data

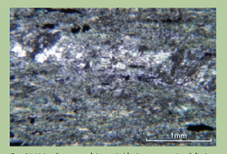


The foliations on the west limb are quite complicated, while in the center (a) and the east limb (b,f) of the outcrop there is a near vertical fold axis. The east limb's counterclockwise and clockwise fold hinges (c,d,e) are more similar to eachother than the west limb. There are no evident conical folds on the east limb.

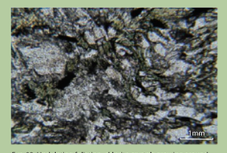
Photomicrographs



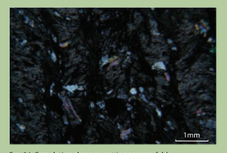
Fyn-01: Large chlorite cross cutting the foliation on an angle.



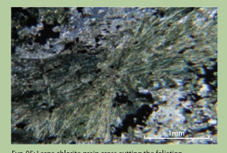
Fyn-01: Vein of quartz, calcite and chlorite cross cutting foliation.



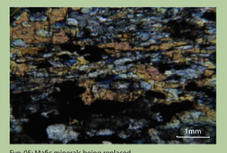
Fyn-02: Undulating foliation, chlorite crystals growing around albite crystals that have been replaced with sericite.



Fyn-04: Crenulation cleavage cutting across a fold.

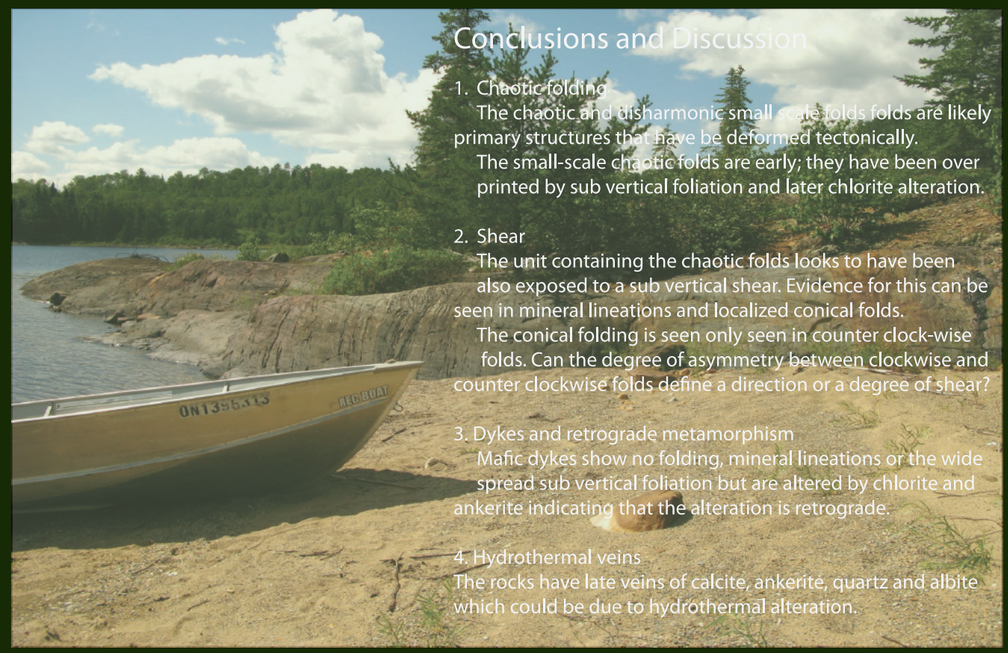


Fyn-05: Large chlorite grain cross cutting the foliation.



Fyn-05: Mafic minerals being replaced.

*Note sample numbers correspond to those on the outcrop map.



Conclusions and Discussion

1. Chaotic folding
   The chaotic and disharmonic small scale folds folds are likely primary structures that have be deformed tectonically.
   The small-scale chaotic folds are early; they have been over printed by sub vertical foliation and later chlorite alteration.

2. Shear
   The unit containing the chaotic folds looks to have been also exposed to a sub vertical shear. Evidence for this can be seen in mineral lineations and localized conical folds.
   The conical folding is seen only seen in counter clock-wise folds. Can the degree of asymmetry between clockwise and counter clockwise folds define a direction or a degree of shear?

3. Dykes and retrograde metamorphism
   Mafic dykes show no folding, mineral lineations or the wide spread sub vertical foliation but are altered by chlorite and ankerite indicating that the alteration is retrograde.

4. Hydrothermal veins
   The rocks have late veins of calcite, ankerite, quartz and albite which could be due to hydrothermal alteration.

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