

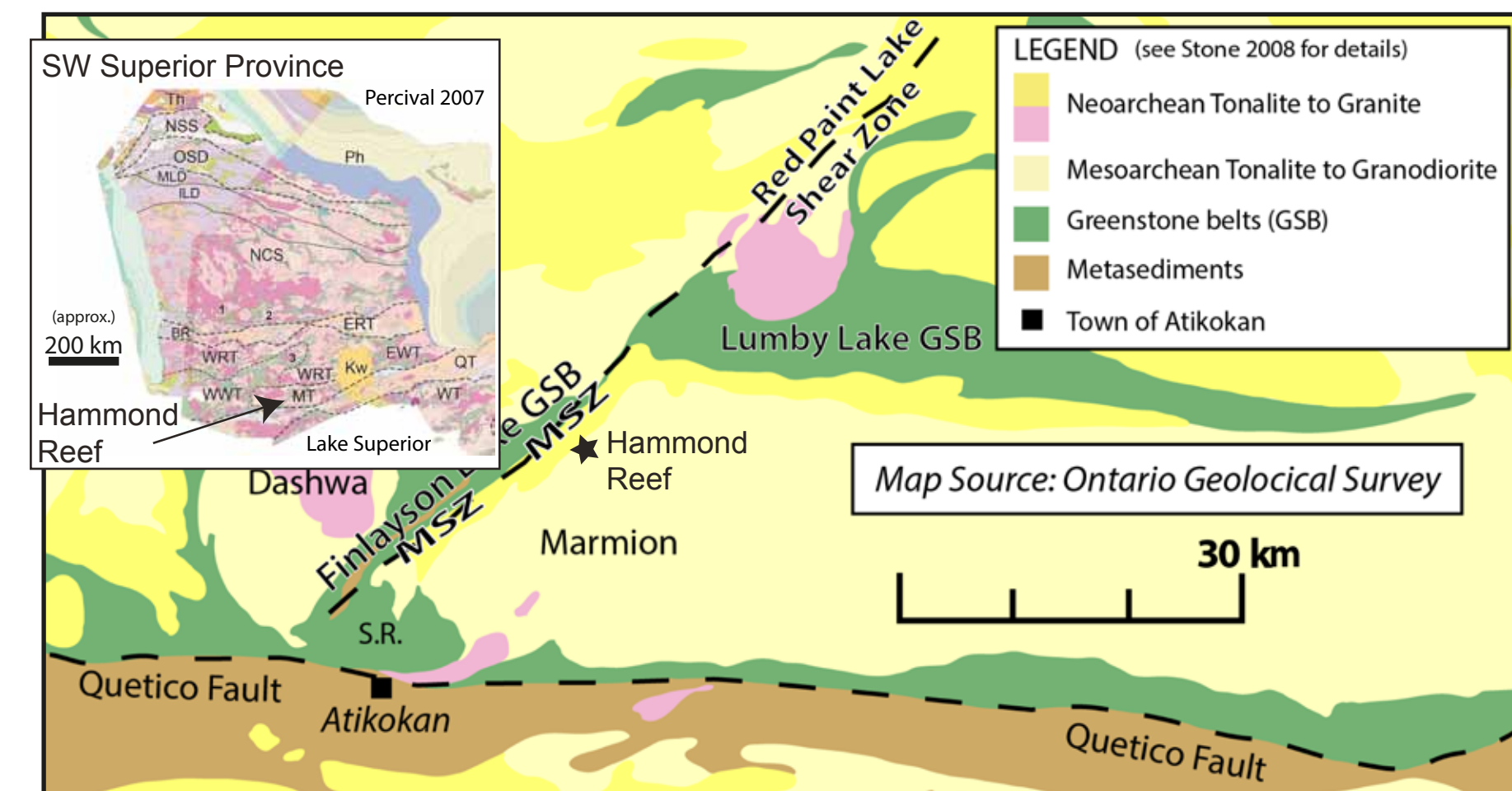
Damaged Goods - Deformation fabrics in a gold-bearing damage zone

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Why are we here?

Permeability of fault zones varies based on localized, distributed and sealed conduits defined by the fault core and related damage zones (Caine et al. 1996). Archean gold deposits are common in fault zones (Vearncombe 1998), but often associated with late sub-static damage not related to the major slip events of the nearby fault. Here we explore the structural and micro-structural controls on permeability related to the Archean Hammond Reef gold deposit in the southwestern Superior Province in order to understand the timing and location of gold mineralization in a previously under-explored tonalite setting.

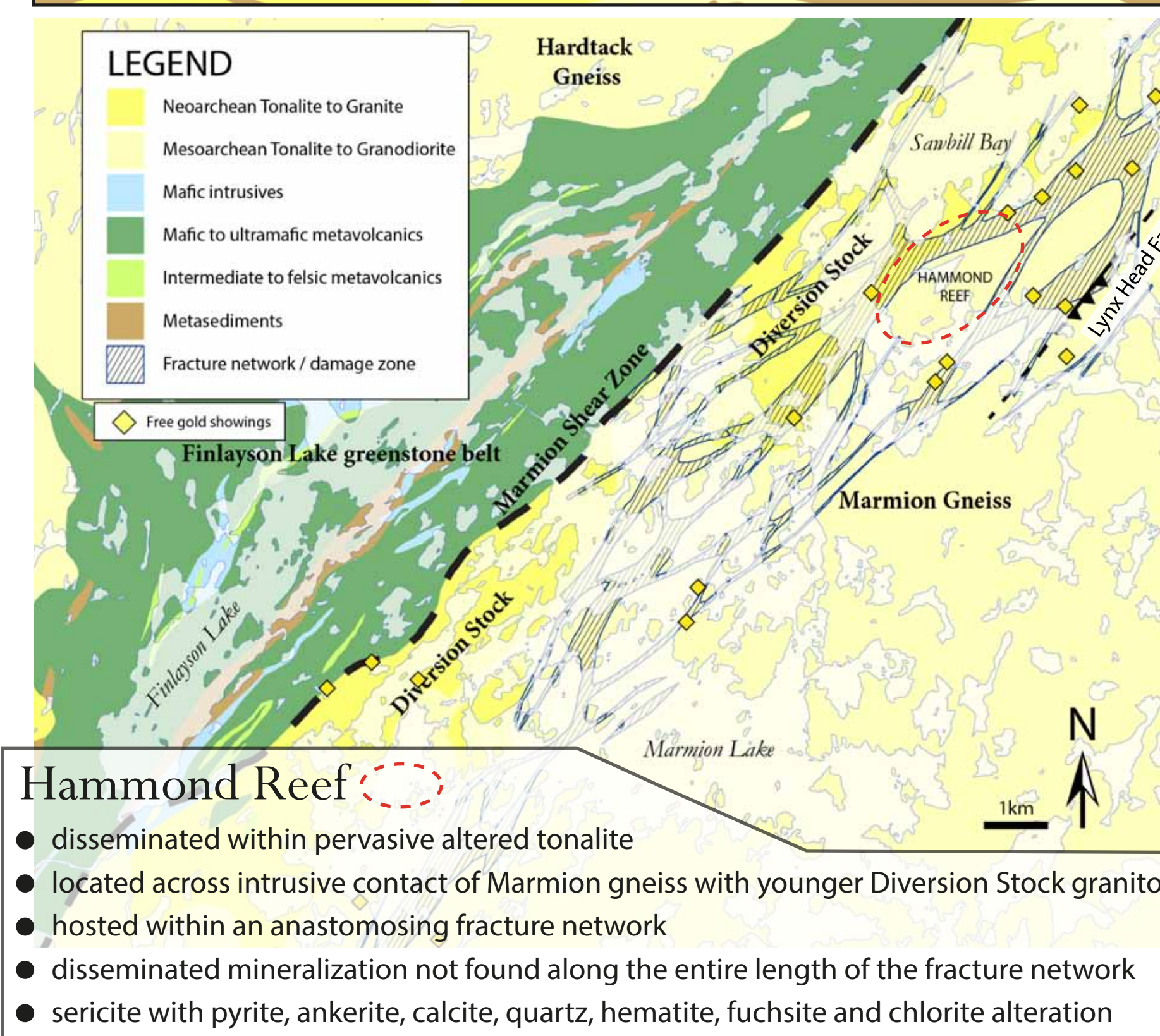
1 A gold-bearing damage zone, Hammond Reef



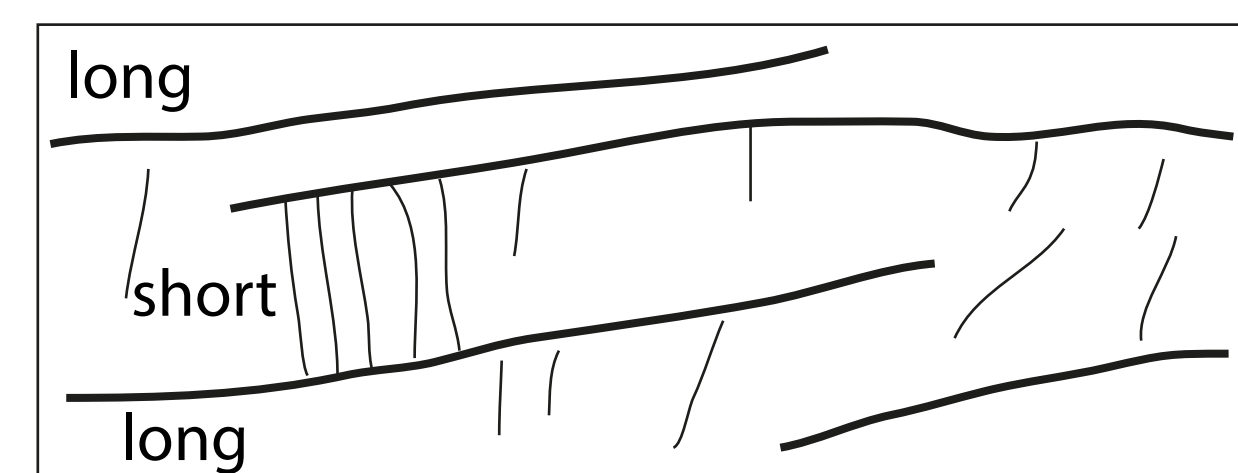
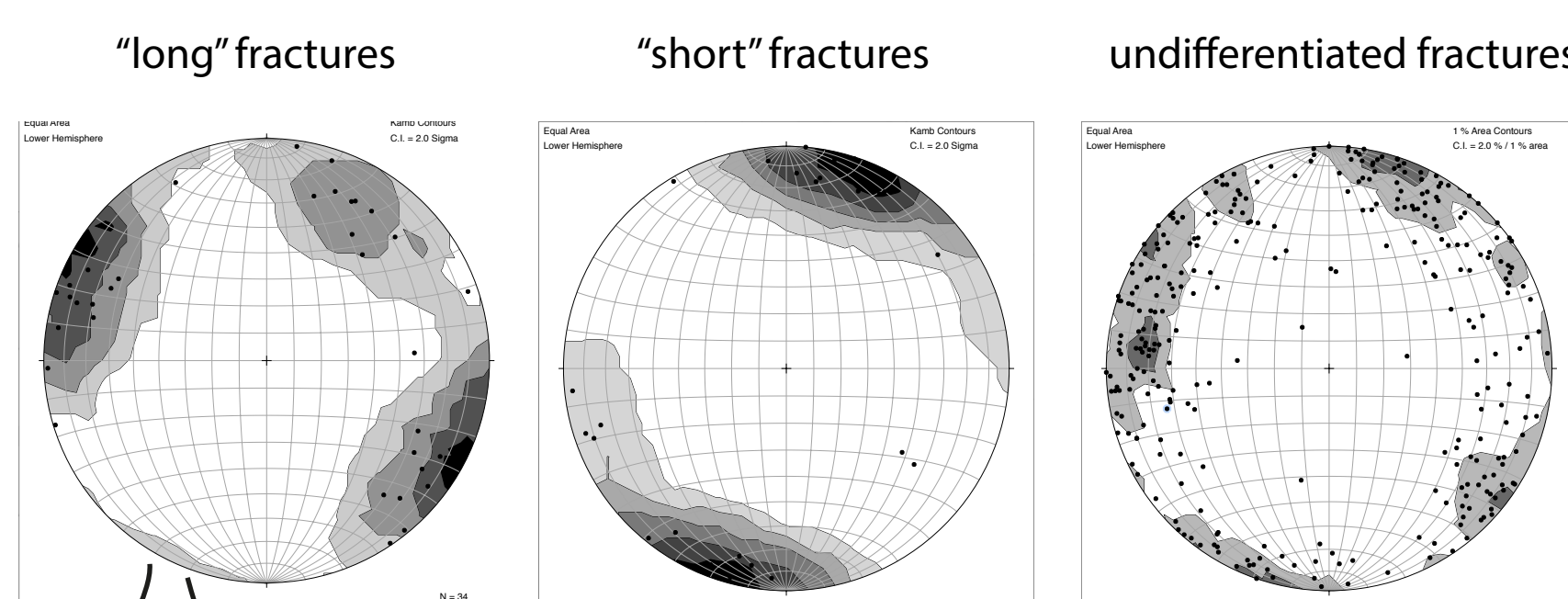
Marmion Shear Zone

- terrane boundary between 2.93 Ga Finlayson Lake GSB and 3.00 Ga Marmion gneiss
- early ductile deformation by at least 2.92 Ga
- multiple reactivation events
- intruded by Diversion Stock granitoids (? 2.8 Ga)
- late stage reactivation (brittle) probably did not accommodate significant offset
- wider damage zone developed in the tonalites
- Possible reactivation during 2.7 Ga Quetico fault activity during docking of Wawa subprovince from the south with northward subduction

dates from Stone (2010) and Percival et al. (2006)



2 Brittle fracture pattern in the tonalites



Fractures in the tonalites

- fracture density varies significantly from 10s to 100s of fractures per meter
- many fractures are vein-filled (epidote, chlorite, sericite, quartz, carbonate, quartz-carbonate)
- mutual cross cutting relations
- pattern of high density "short" fractures perpendicular to lower density "long" fractures
- short fractures terminate at long fracture intersect
- all the fracture data plots two dominant NNE and ESE orientations
- very variable fracture orientations locally and regionally
- overall pattern matches the "long-short" pattern

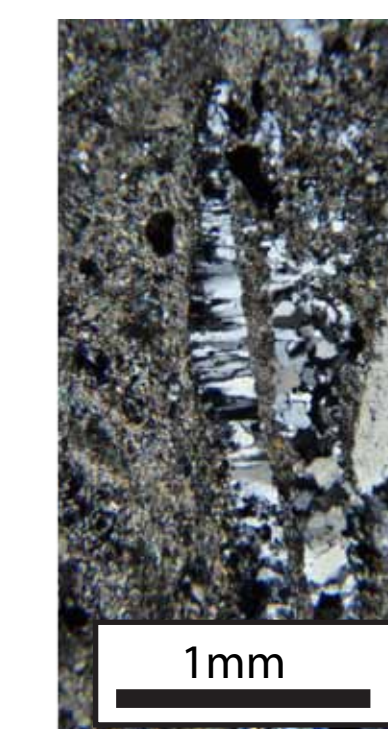
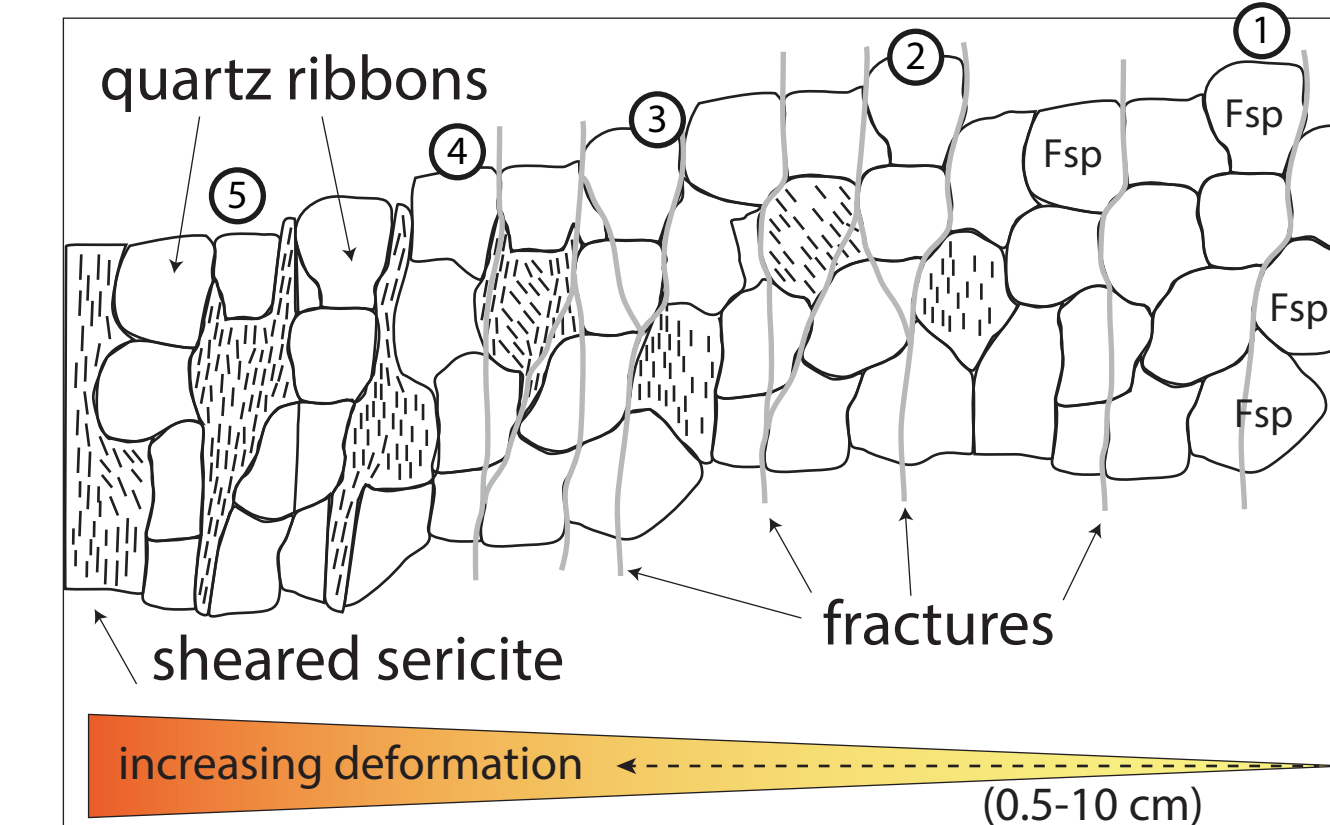
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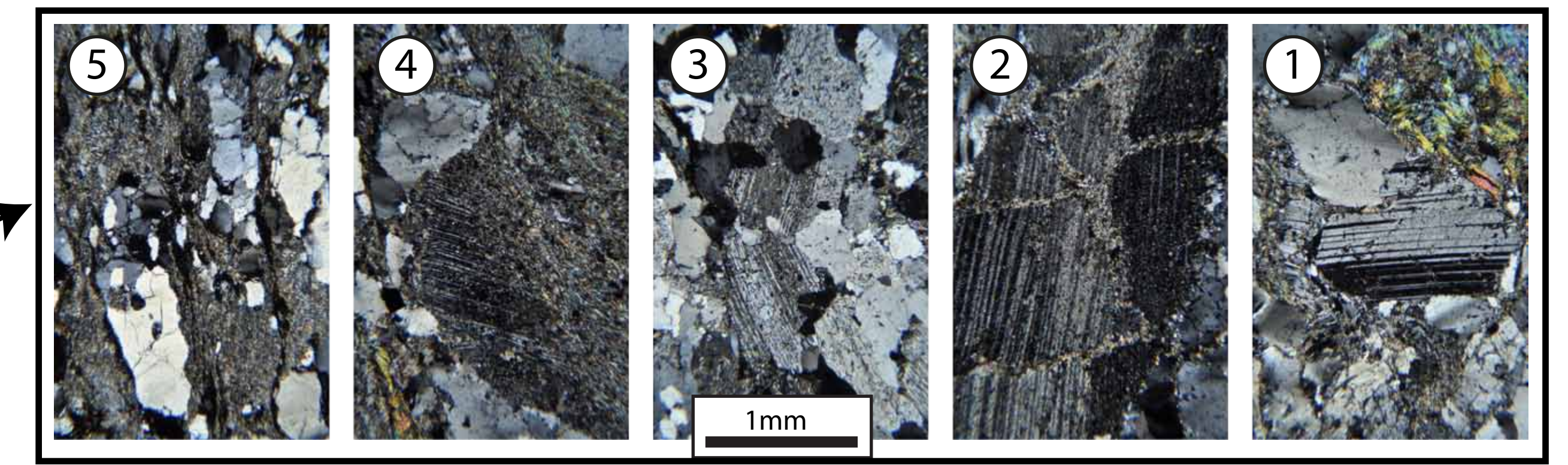
3 Alteration and spaced cleavage foliation



schematic of localisation



opening quartz vein parallel to cleavage foliation.
- opening-closing strain?



increasing deformation

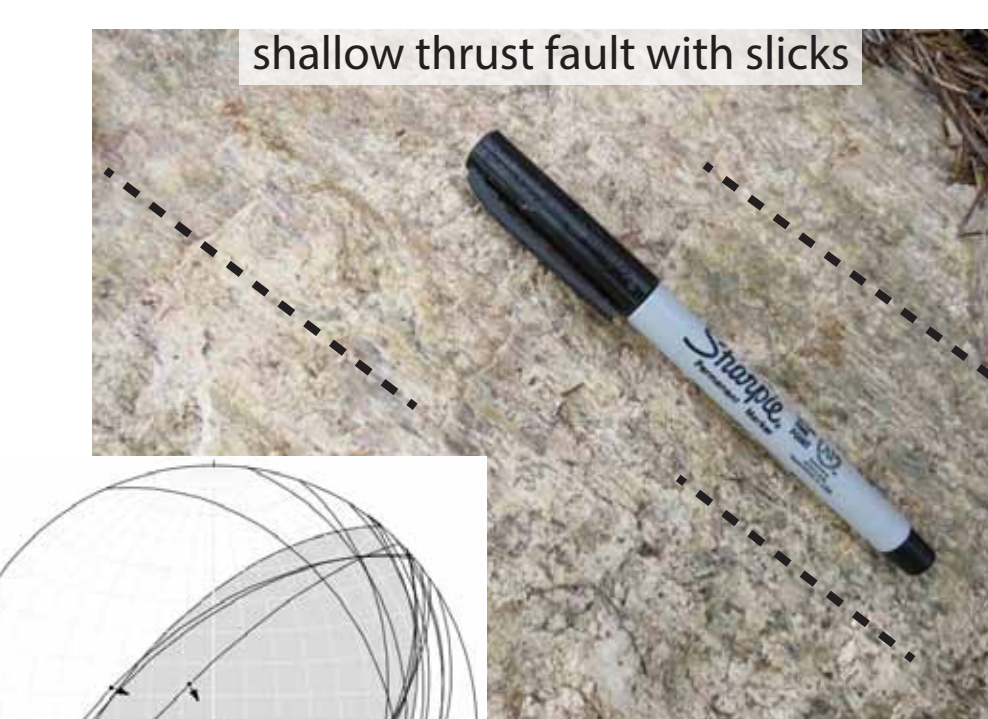
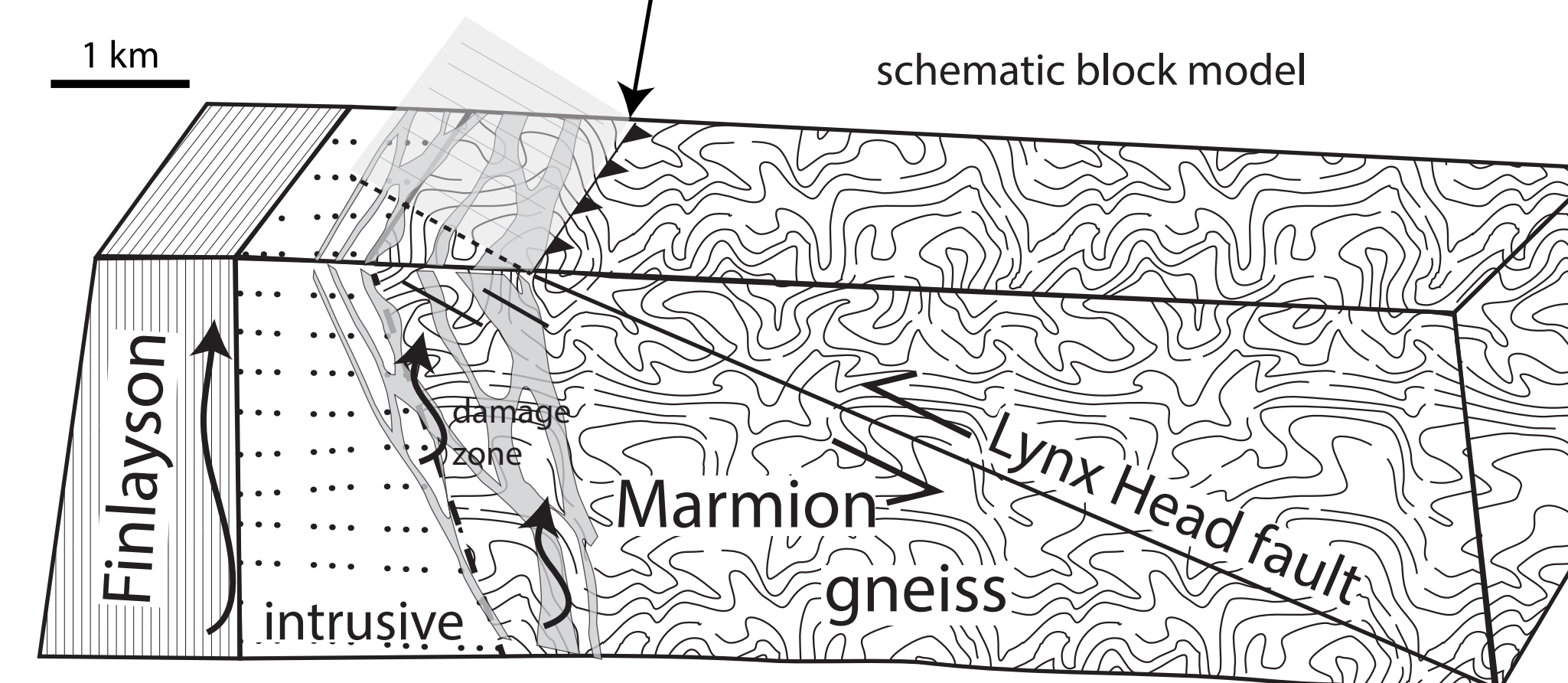
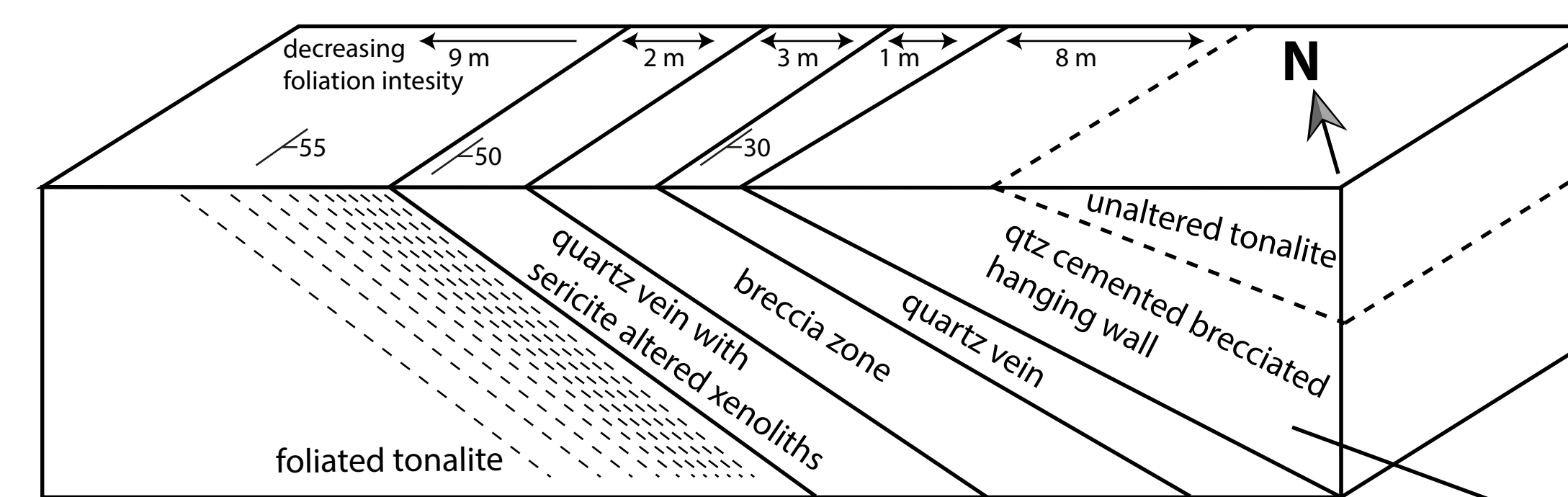
fracturing and alteration

static alteration

Anastomosing Fracture Network

- brittle deformation of unaltered tonalites (1)
- sericitisation of feldspars (Fsp) along fractures and grain boundaries (2)
- progressive alteration of feldspars (3,6)
- sericite dominant zones promote flattening and cleavage (4)
- spaced cleavages promote further localisation of alteration and deformation (5)
- flattening and minor shearing of sericite spaced cleavage defines the foliation fabric (5)
- foliation trends NE, subparallel to Marmion Shear Zone
- intensely foliated units show aggregates of quartz ribbons with long axes parallel to foliation (5)
- unfoliated lenses are protected from flattening/shearing, but show pervasive sericitisation of feldspars (pseudomorphs) (6)

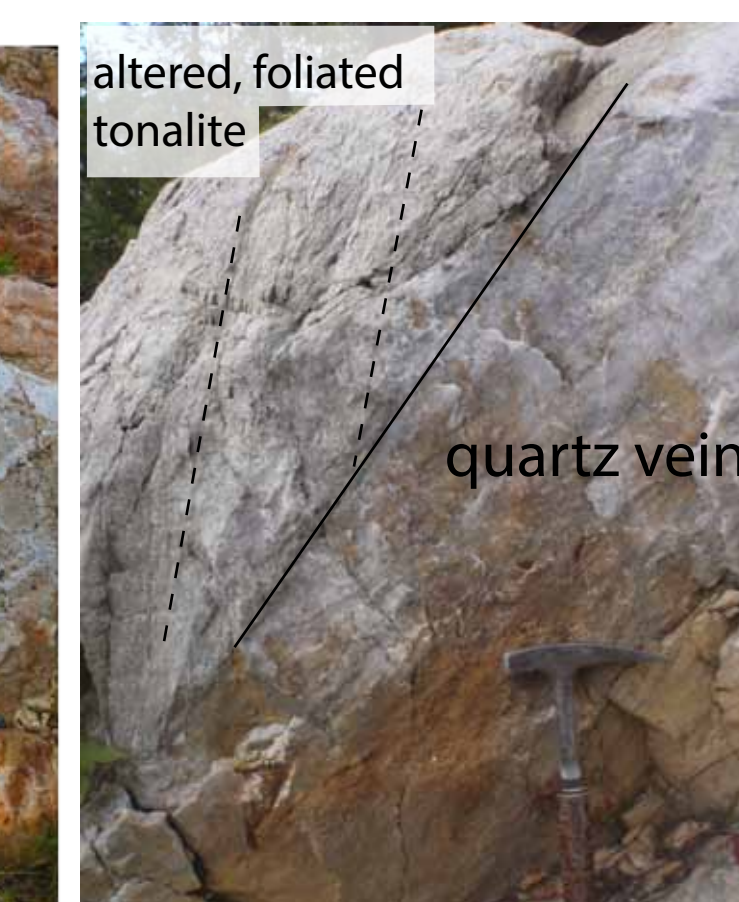
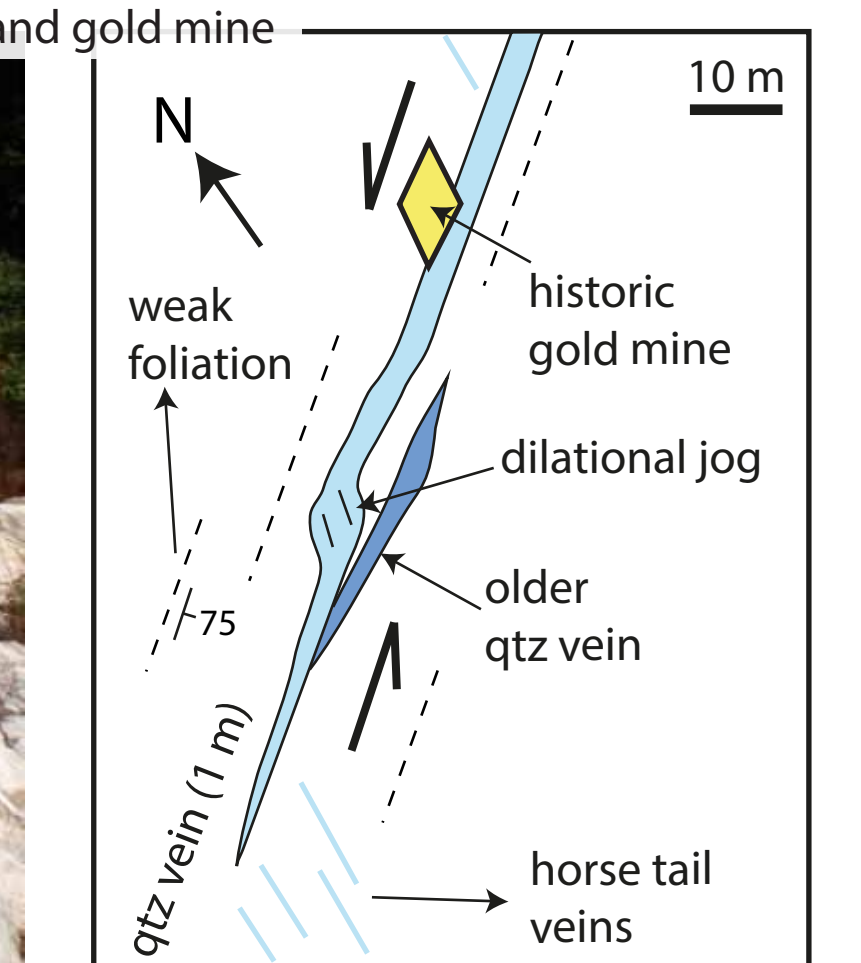
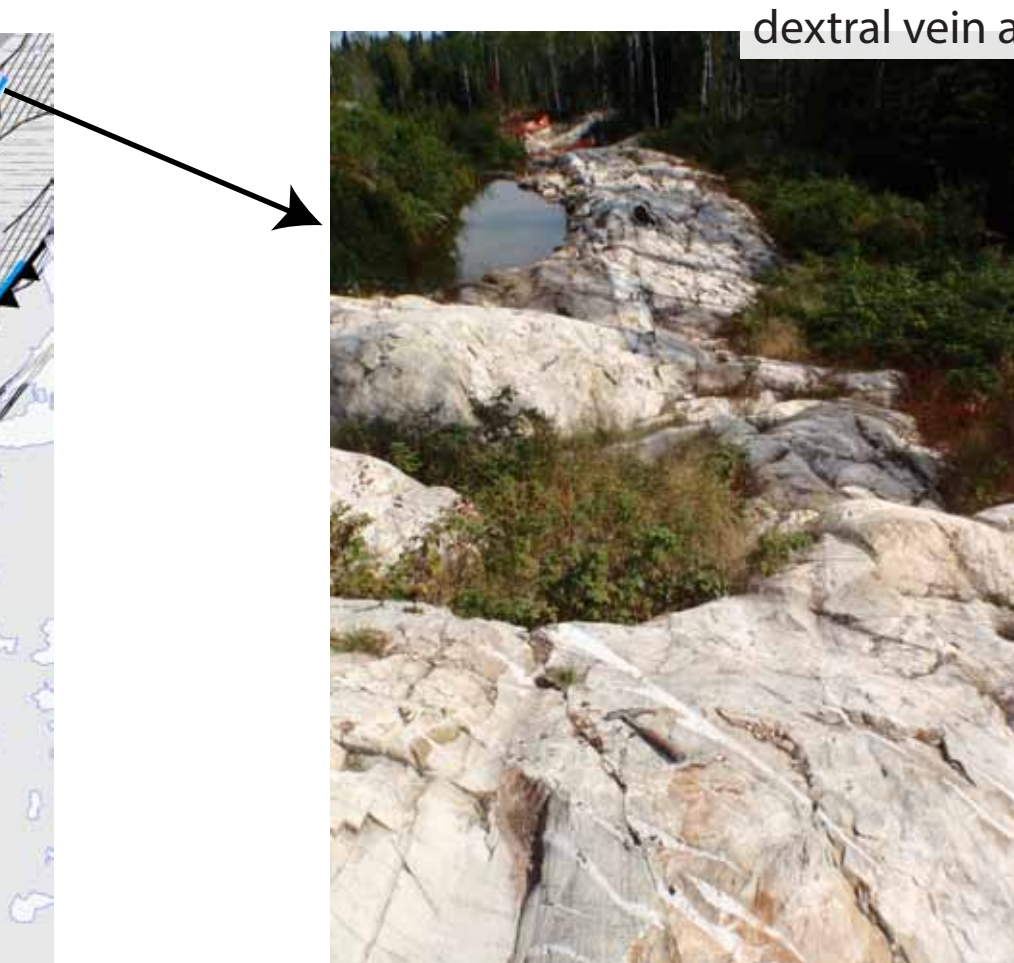
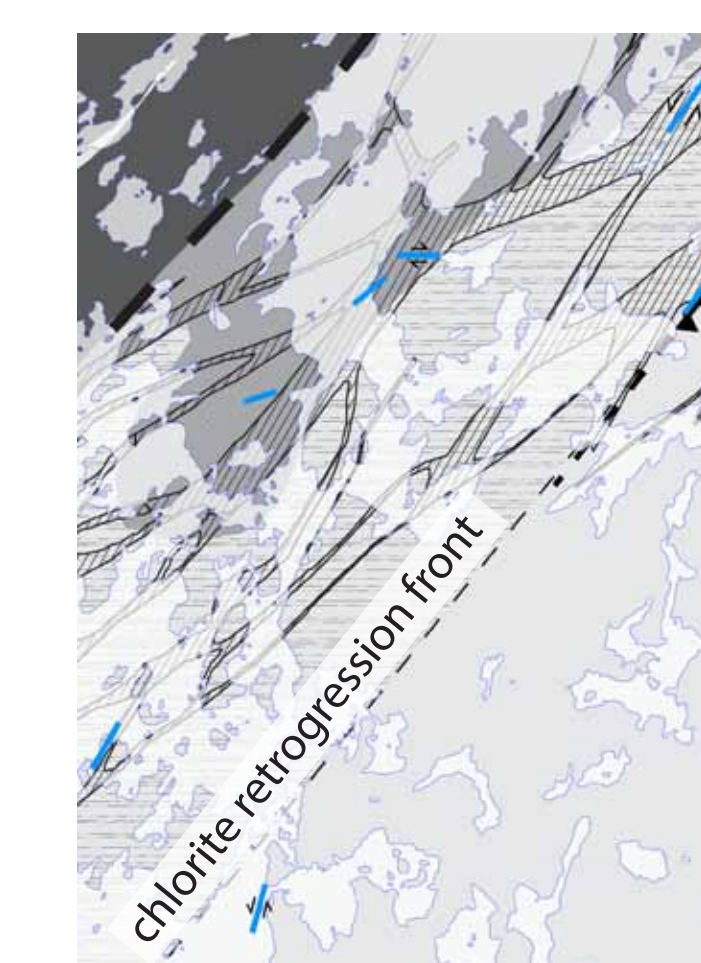
4 Late shallow thrust faults



Lynx Head Fault

- shallow southeast dipping thrust fault
- eastern limit of regional chlorite retrogression after amphibole
- cross cuts anastomosing fracture network
- 2 zones of quartz veins are emplaced along Lynx Head Fault with brecciated hangingwalls
- Lynx Head Fault consistent with regional late shortening event across the Marmion Shear Zone (Backeberg et al. 2014)
- Is it tectonically related to the dextral transpression across the Quetico fault during 2.7 Ga Superior Province amalgamation?

5 Large quartz veins and gold

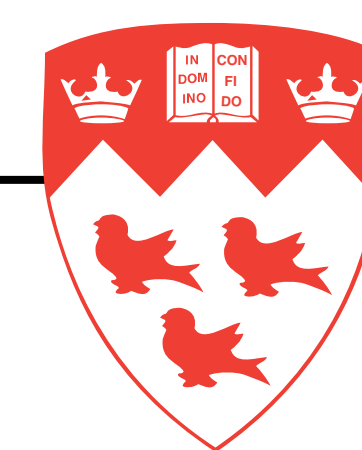


Quartz veins

- multiple events
- emplaced along pre-existing structures
- locally quartz-cemented brecciated wall-rock
- cross cuts anastomosing fracture network
- visible gold associated with large quartz veins
- dextral and sinistral offset associated with quartz veins, consistent with NW-SE shortening
- latest structural activity in the Marmion tonalite

Implications and open questions

- brittle damage zone related to shallow reactivation of Marmion Shear Zone (see Backeberg et al. 2014)
- Diversion Stock intrusive acts as rigid block along shear zone - fluid barrier?
- anastomosing fracture network accommodates flattening along sericite altered feldspars
- Is feldspar alteration promoted by the early perpendicular fracture pattern? Unloading/exhumation
- late shallow faults cut altered tonalites; Does Lynx Head Fault act as fluid barrier to upward fluid flow?
- damage zone and thrusts consistent with late shallow NW-SE shortening around Marmion Shear Zone
- Quartz veins carry gold and are last event. Is the disseminated alteration and Au-mineralization due to the Lynx Head Fault fluid barrier at Hammond Reef? Why is disseminated gold not along entire damage zone?
- does static alteration and localized flattening of Feldspars promote pervasive permeability in the tonalites?
- Hammond Reef gold is not a porphyry style deposit - possibly related to 2.7 Ga Superior Province tectonism.



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