Magmatic-Hydrothermal Gold Systems in the Archean of Northern Ontario, Canada: Examples of Syenite-Associated and Porphyry-Type Au-(Cu) Deposits

By

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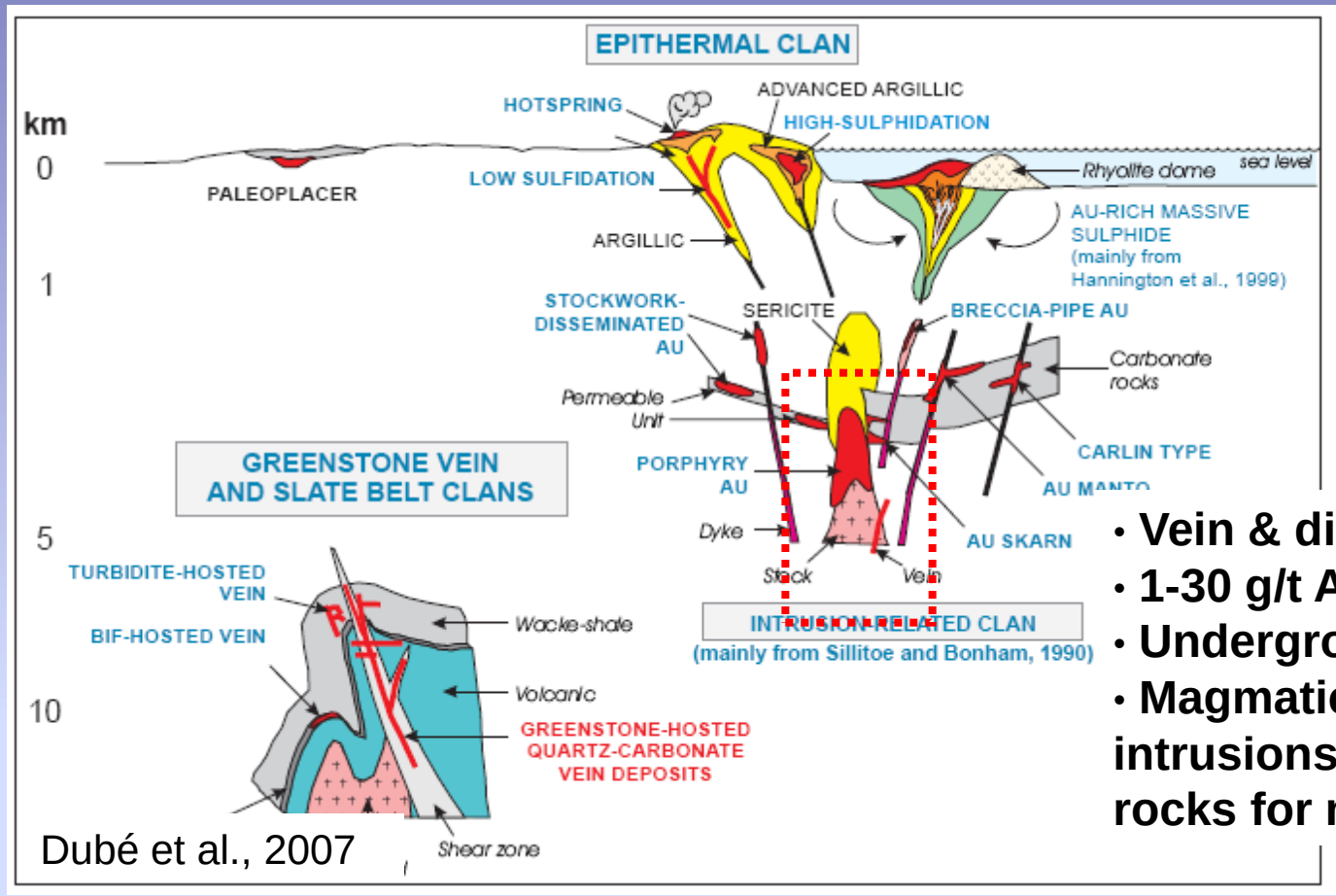
Natural Resources Canada
Ressources naturelles Canada

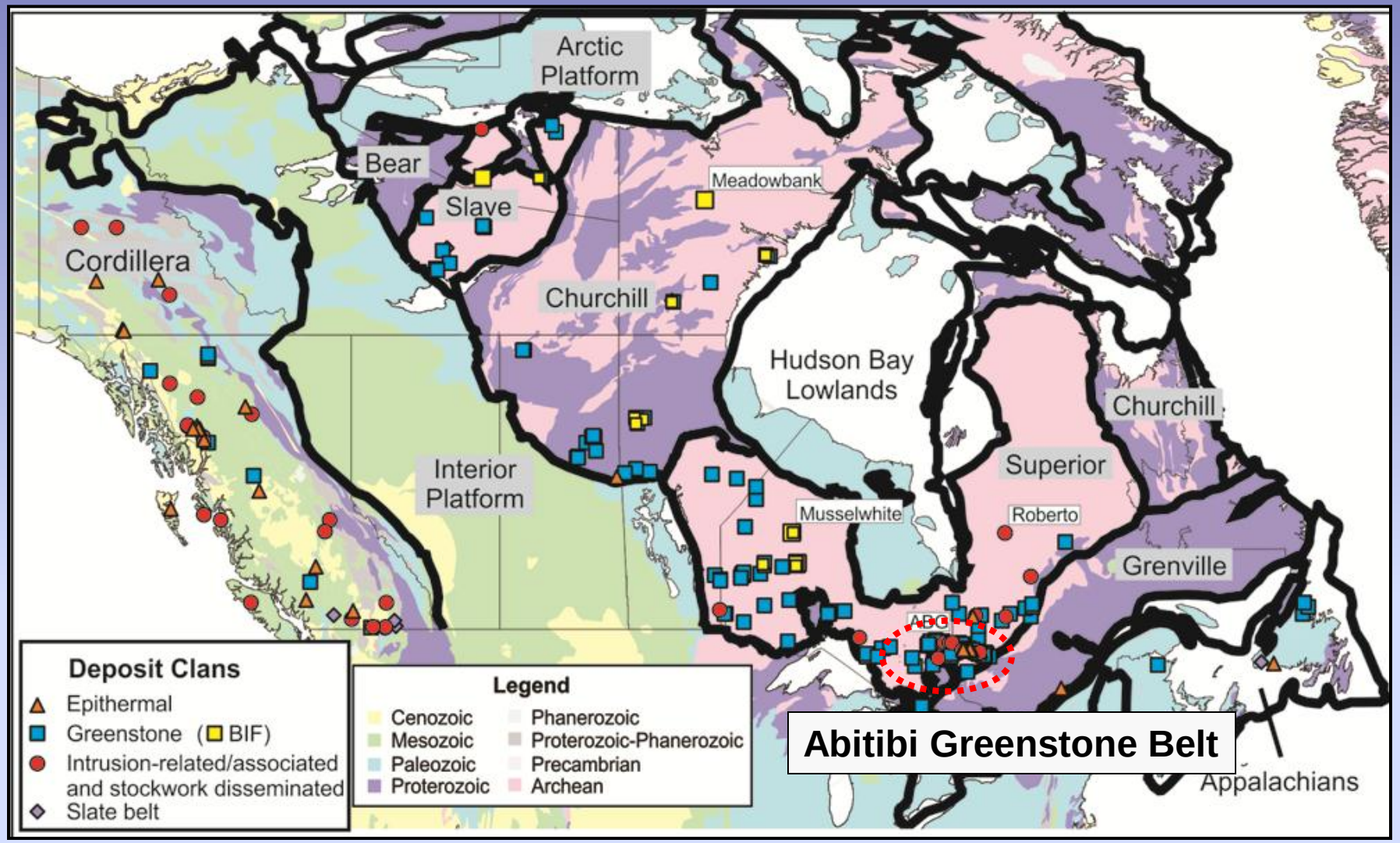


Dubé et al., 2007

- **Vein & disseminated**
- **1-30 g/t Au**
- **Underground & open pit**
- **Magmatic origin or are the intrusions just good host rocks for mineralization?**

Syenite hosted – vein and disseminated type mineralization; associated with mafic to felsic syenites; variable alteration (potassic, sodic, phyllic, hmt/mt, sulfide, carbonate, epidote, tourmaline); Au-Ag-Te-Cu-W-Mo-F, B association.

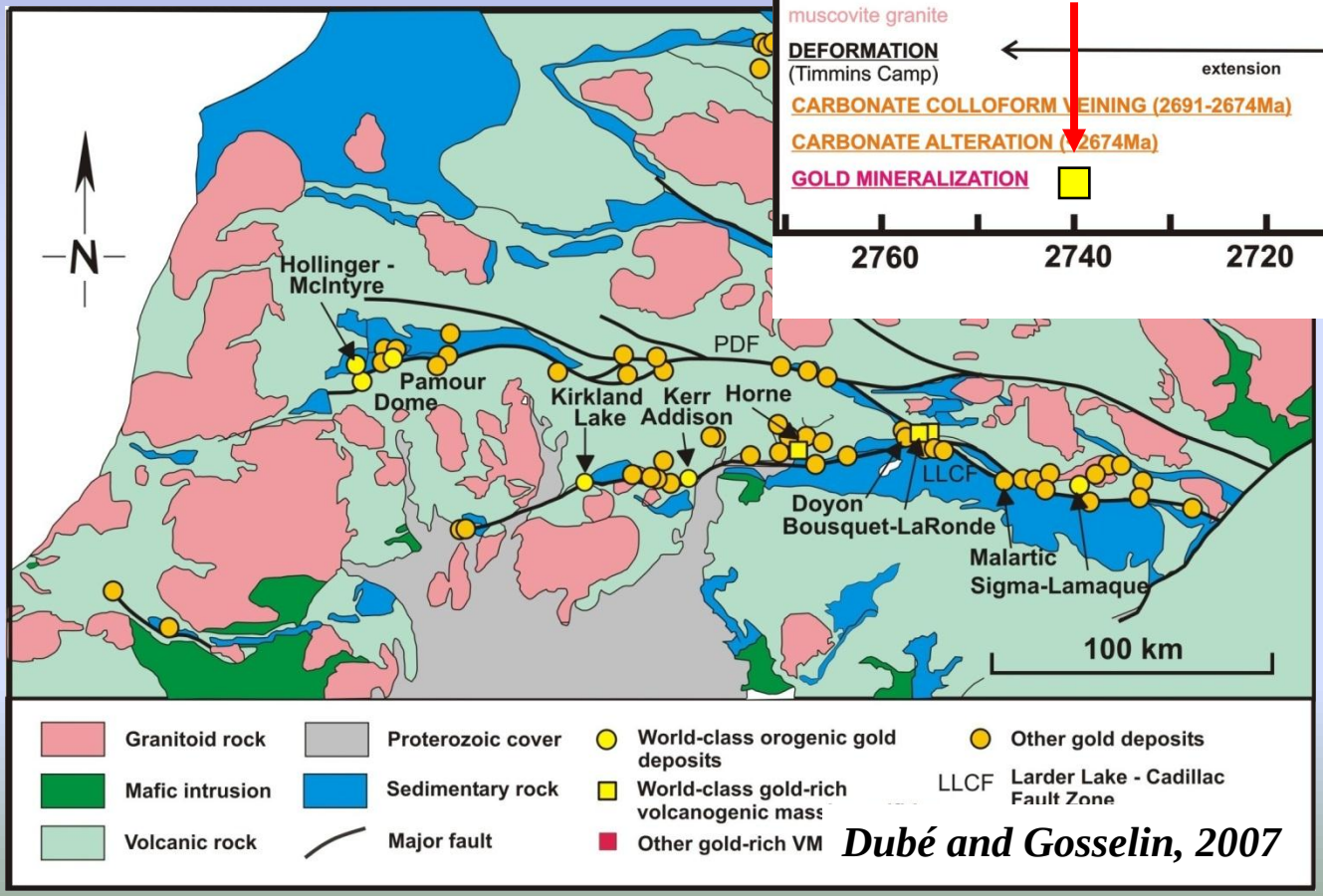
Tonalite-diorite – disseminated mineralization in a potassic altered (biot) breccia system (magmatic & hydrothermal).

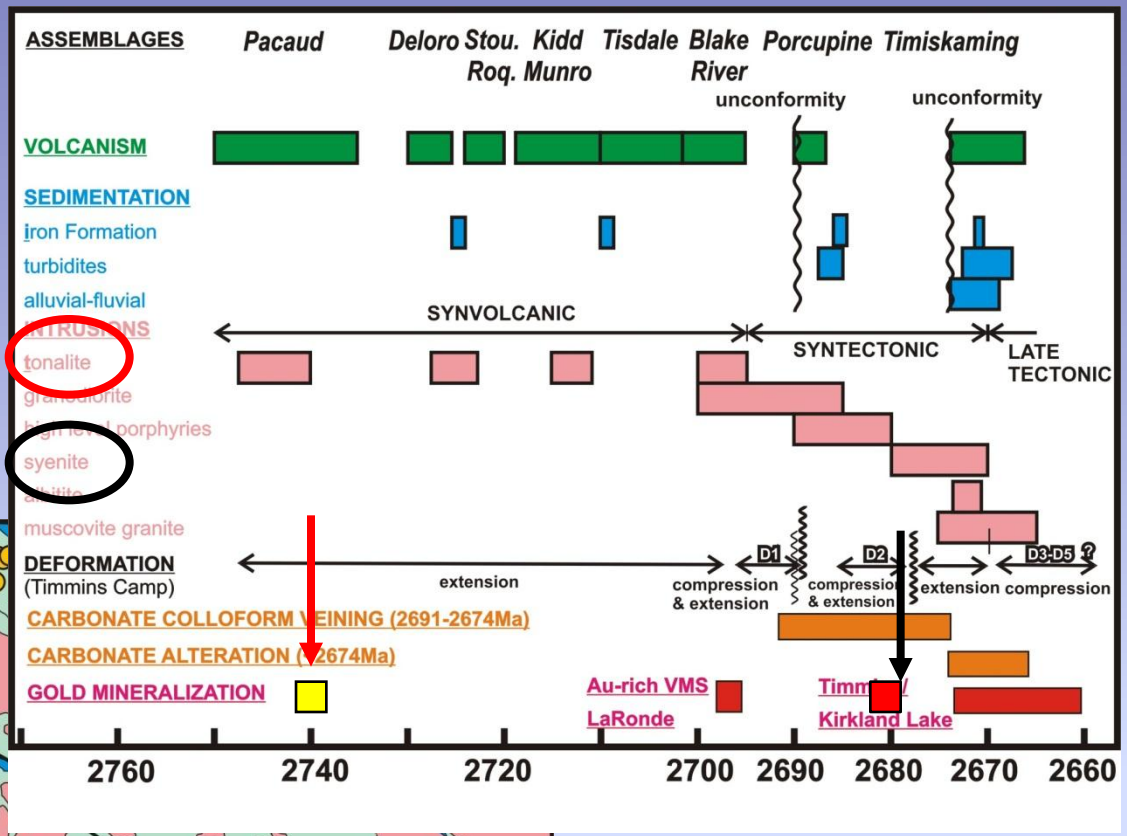


Examine intrusion-related Au deposits in the 2750-2670 Ma Abitibi-(Swayze) Greenstone Belt of the Superior Province, Canada; historical production of about 150 M oz Au.

Deposits:

- Near large structural breaks (PDFZ, CLLFZ)
- two deposit types: tonalite, syenite
- Syenite type in basins filled with terrestrial sediments and alkaline volcanics

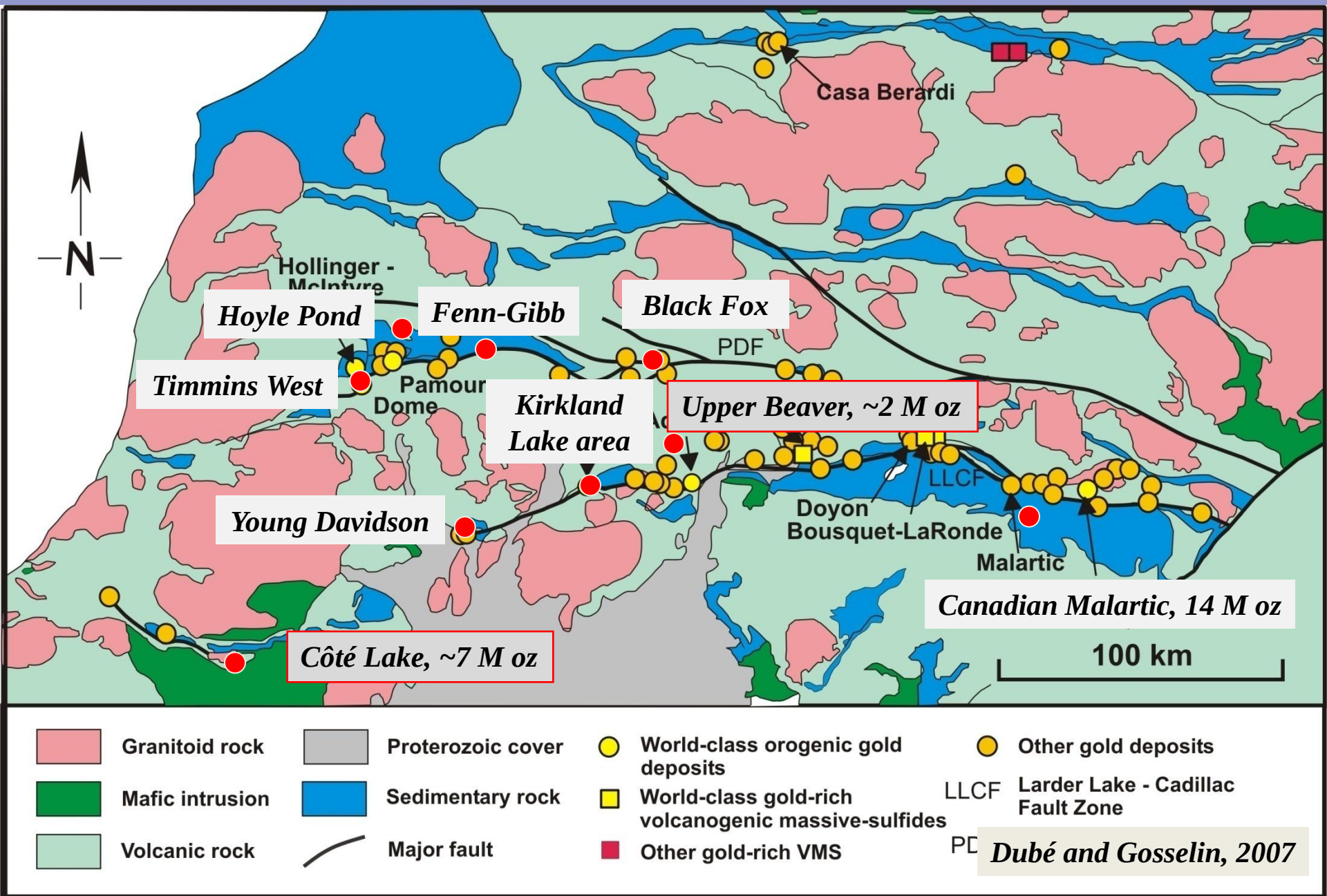




Dubé and Gosselin, 2007

Carbonate alteration

GEOLOGICAL TRANSECT (West-East)



Features of Syenite-Associated Gold Deposits:

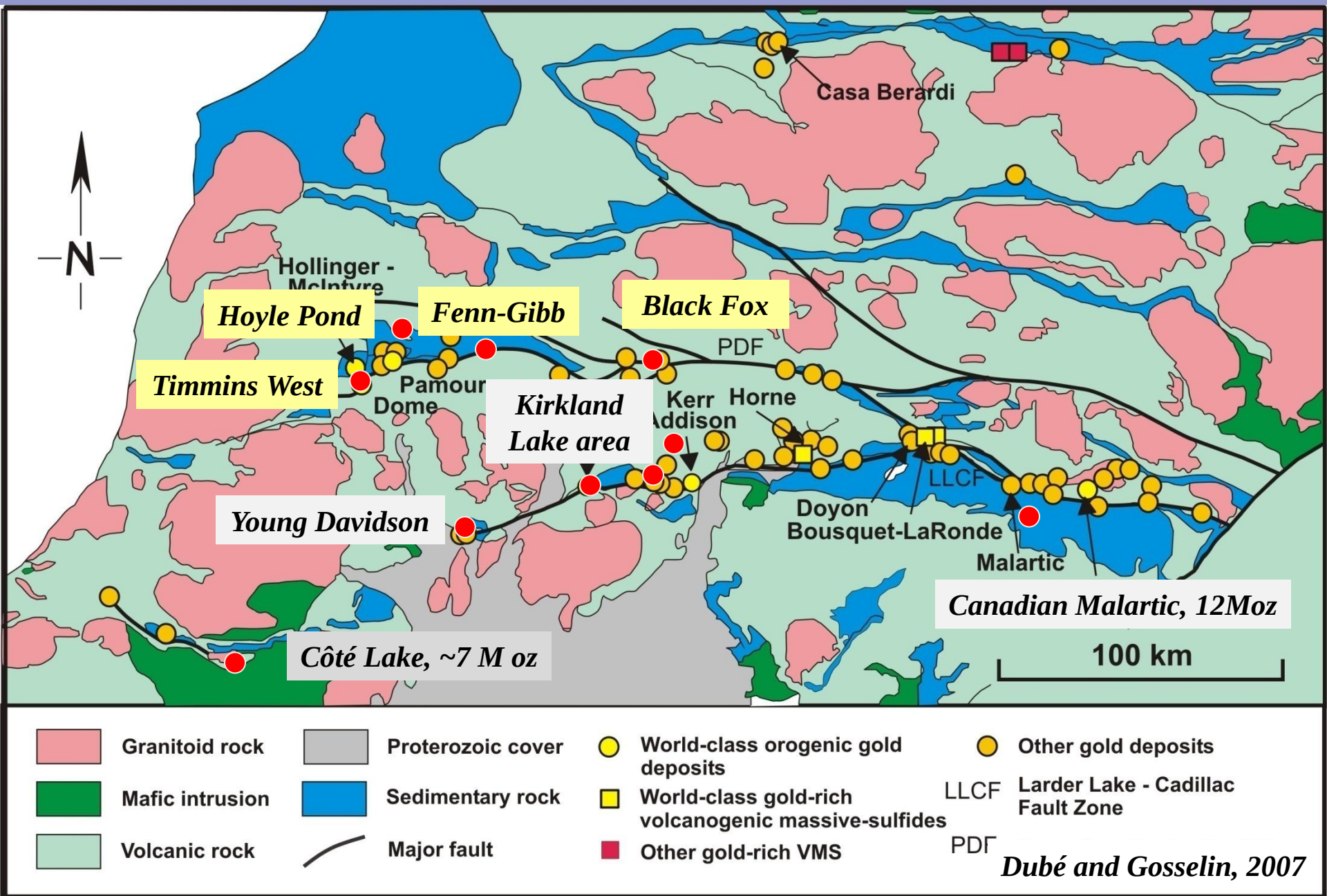
• Syenites are late-stage in the evolution of the Abitibi Greenstone Belt (<2680 Ma) and oxidized mafic (pyx-amph) to felsic (qfp) intrusions;

• Host rocks are variable, but often hosted by the Porcupine or Timiskaming sedimentary (volcanic rocks);

• Mineralization styles (vein vs. disseminated), associated elements (Ag-Cu-Te-W-Bi-Mo-F-B) and alteration variable among deposits;

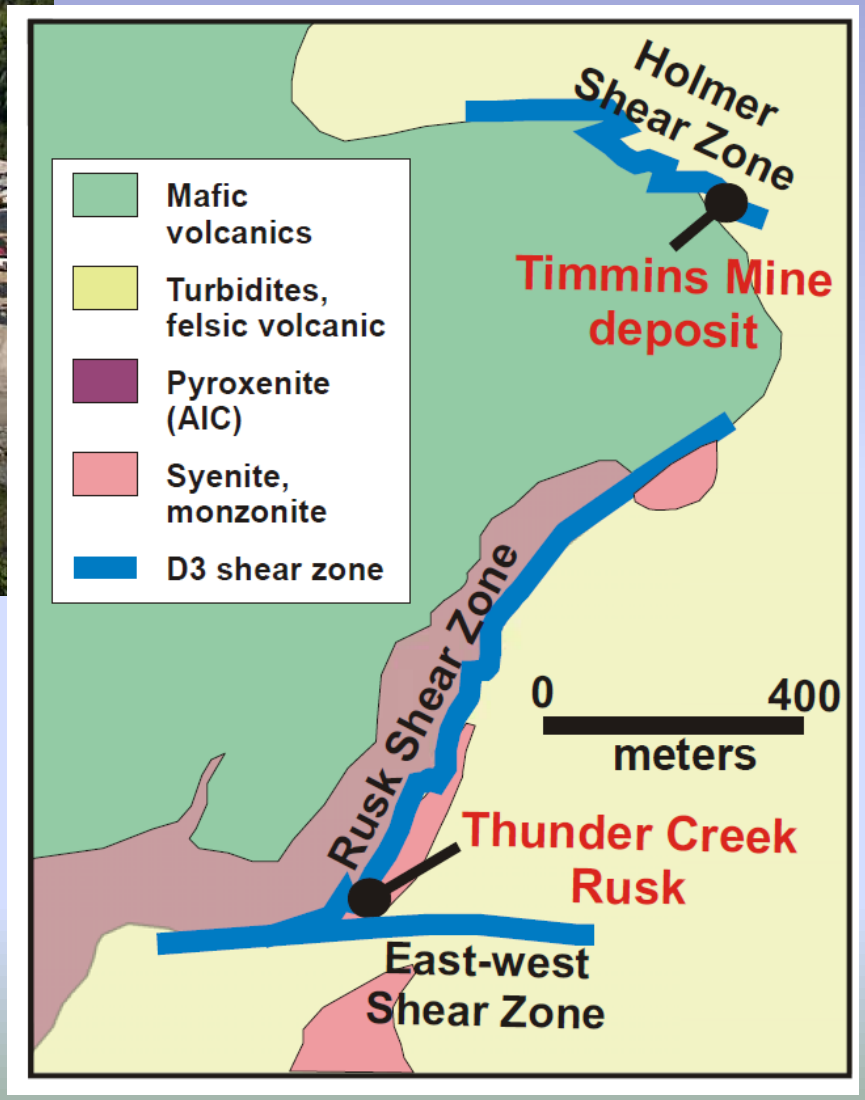
• **Mineralization is structurally controlled and fluids are late-stage, thus these MUST be long lived magmatic systems.**

Gold Deposits along the Porcupine-Destor Fault Zone

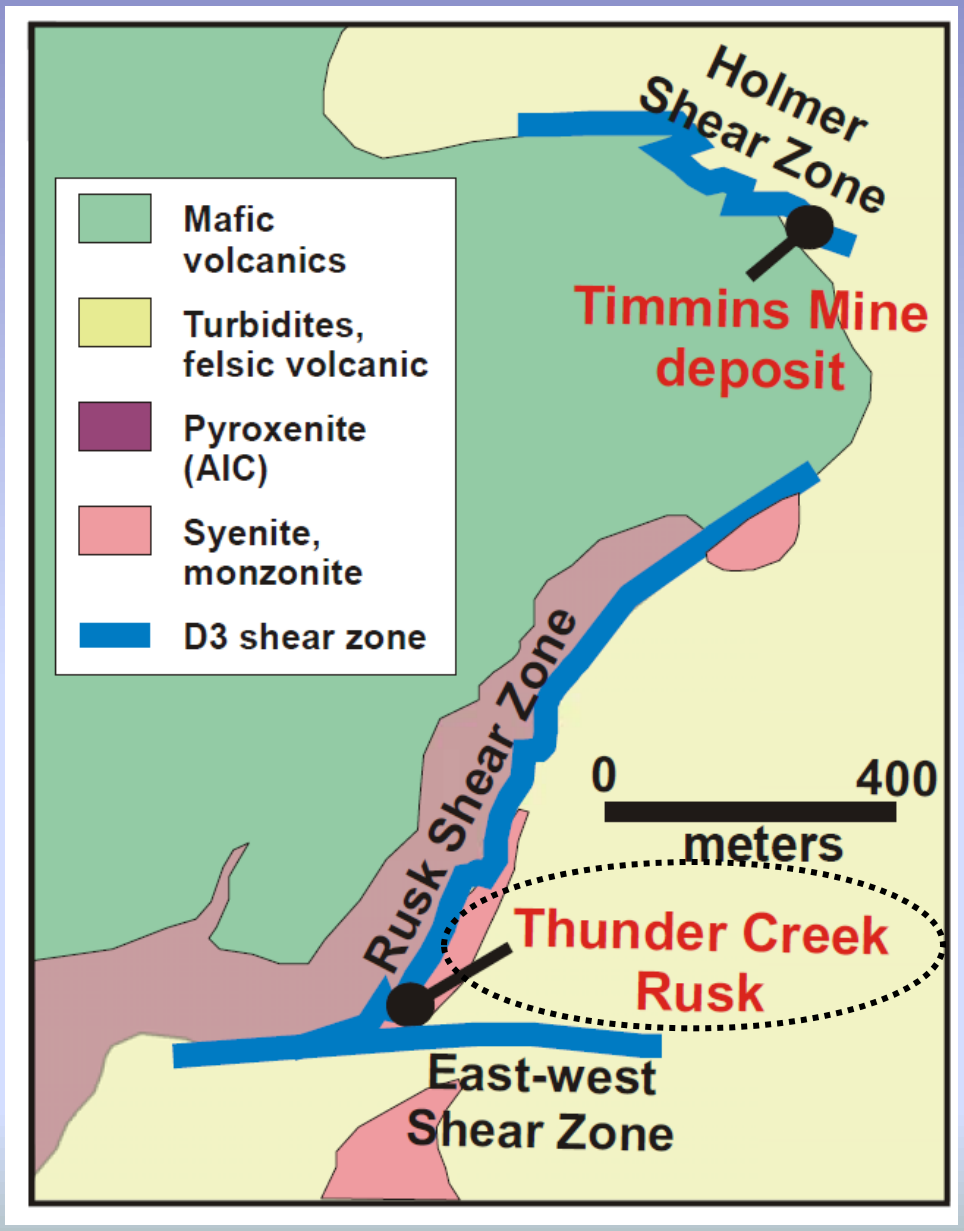


Dubé and Gosselin, 2007

LAKE SHORE GOLD: West Timmins and Thunder Creek Syenite-Associated Deposits



- Underground operations in syenite- and wallrock – hosted mineralization;
- Mineralization within shear zones (HSZ, RSZ) with hydrothermal overprint;
- Timmins West 4.2 Mt @ 5.4 g/t (0.83 M oz Au)
- Total reserves of several M oz

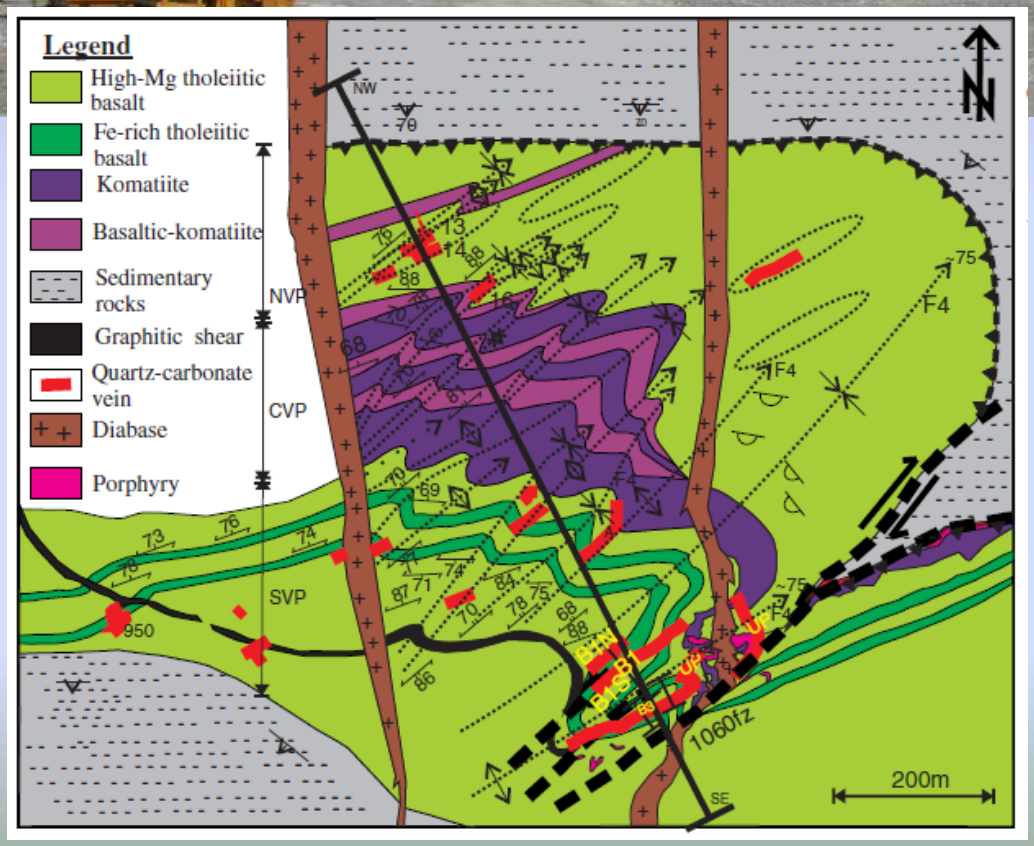


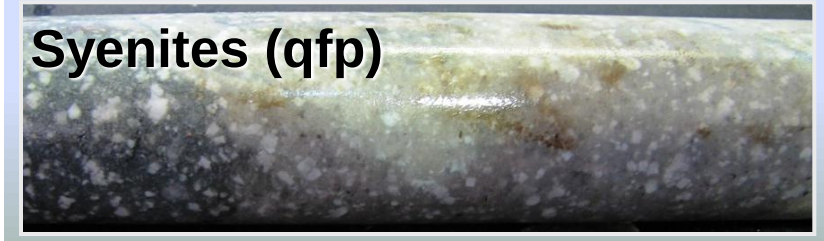
Deformed syenite

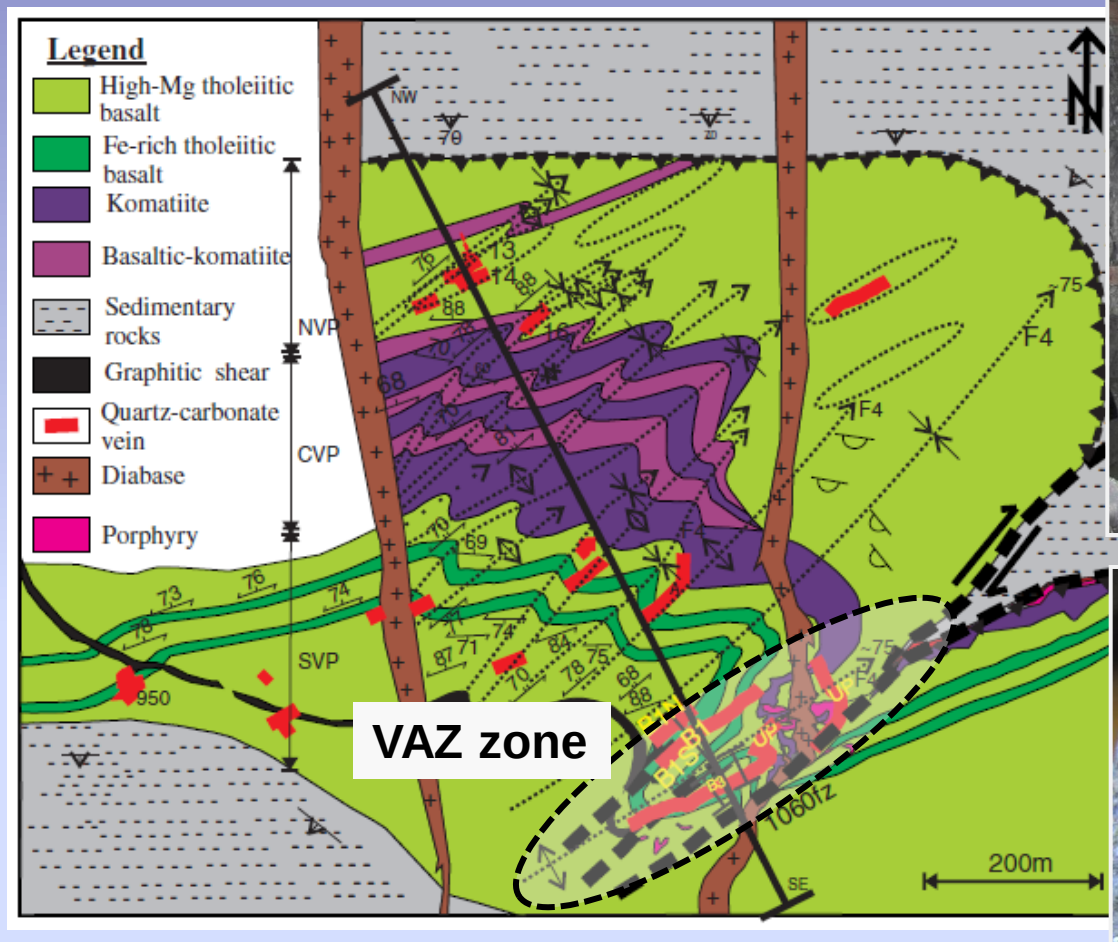
Deformed syenite overprinted by pyrite-carbonate-sericite and Au

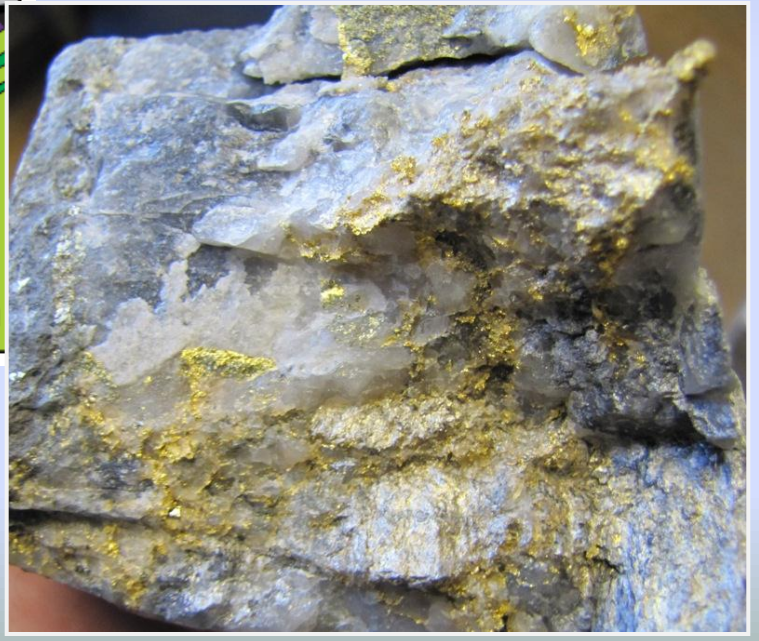
Quartz-tourmaline fibre veins

GOLDCORP Hoyle Pond Deposit (>2.5 M oz since 1985)





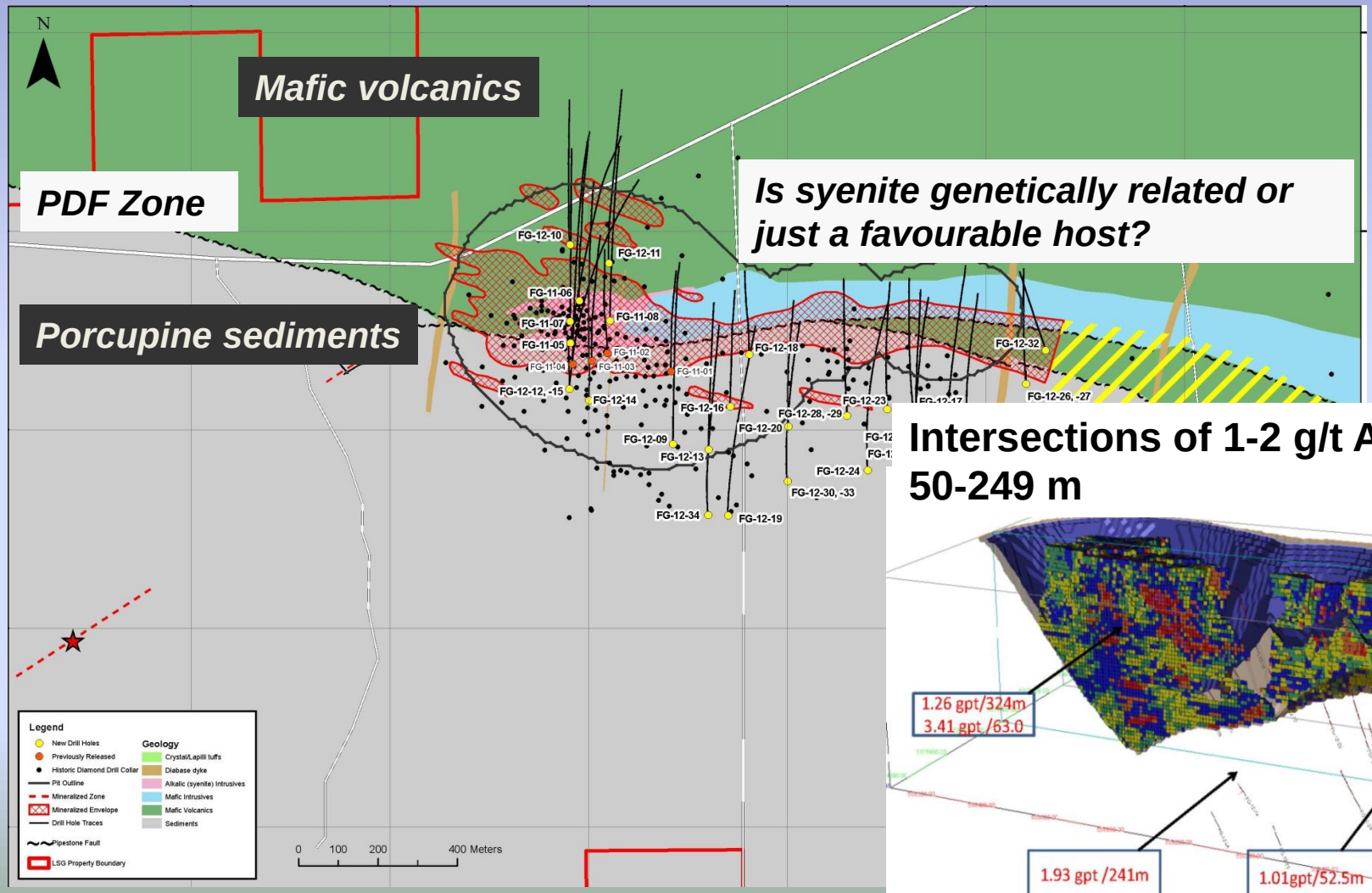




Is there a spatial and temporal association with these deeper syenite/porphyry dykes?

LAKE SHORE GOLD: Fenn-Gibb Deposit:

- Mineralization is centred on syenite emplaced in a bend in the PDFZ.
- Ore as veinlets and disseminations in altered syenite.
- Resources (pit shell) of 65 Mt a@ 0.96 g/t (2.1 M oz).
- ***Indicates viability of low-grade, high-tonnage open pit operations.***



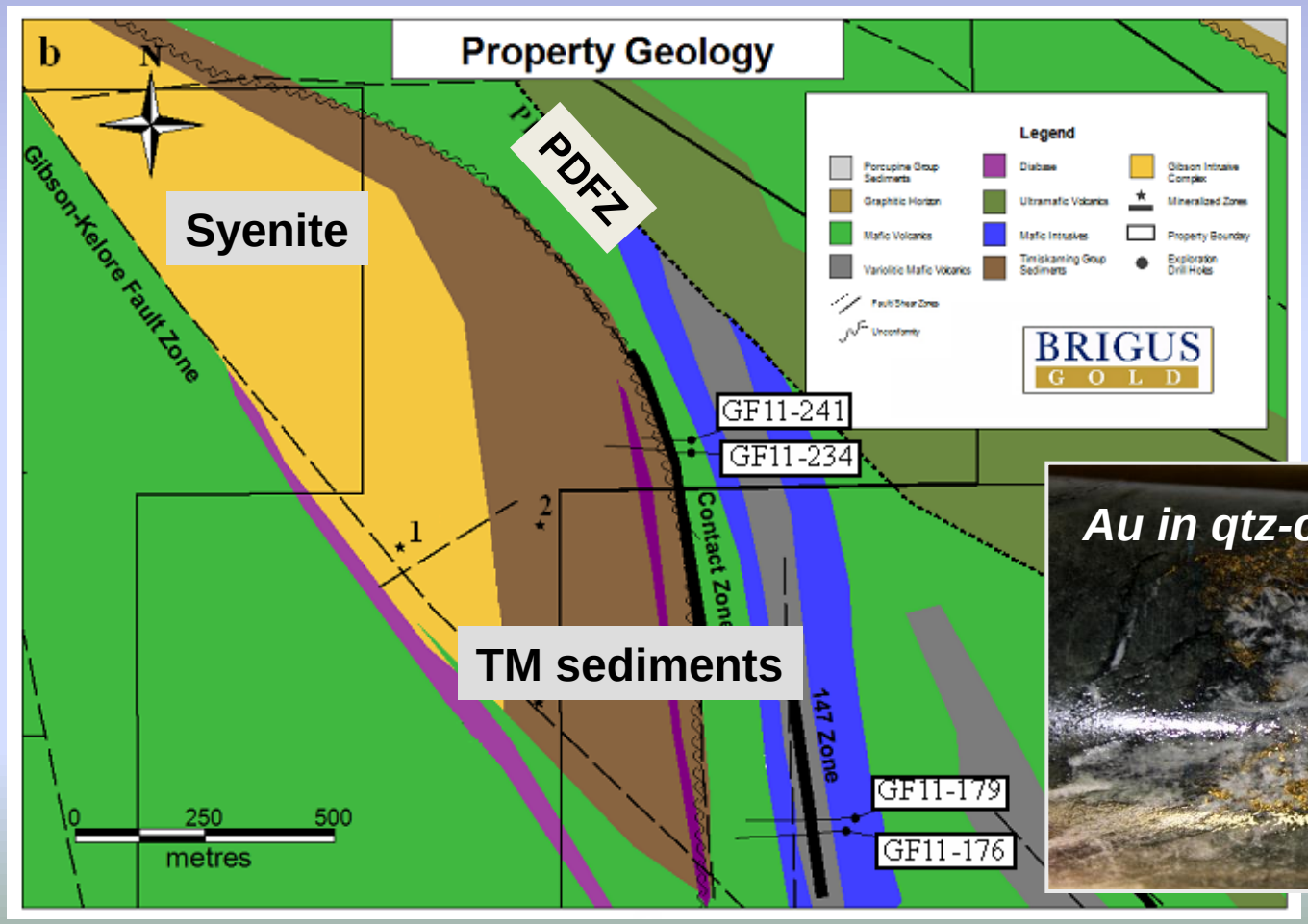
Intersections of 1-2 g/t Au over 50-249 m

BRIGUS GOLD: BLACK Fox Complex

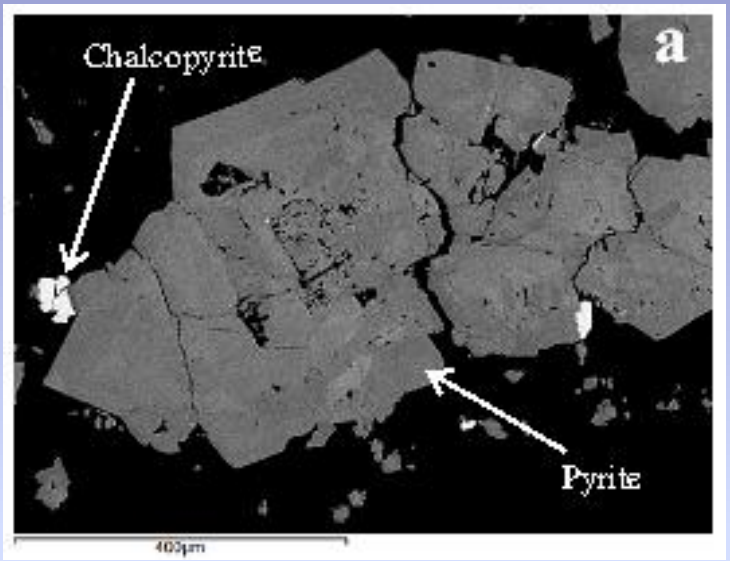
- Open pit (3g/t) and underground (6 g/t) producing 70,000 oz/yr.
- Mineralization in veined (Qtz-Carbonate) and altered syenite and host mafic volcanic rocks.

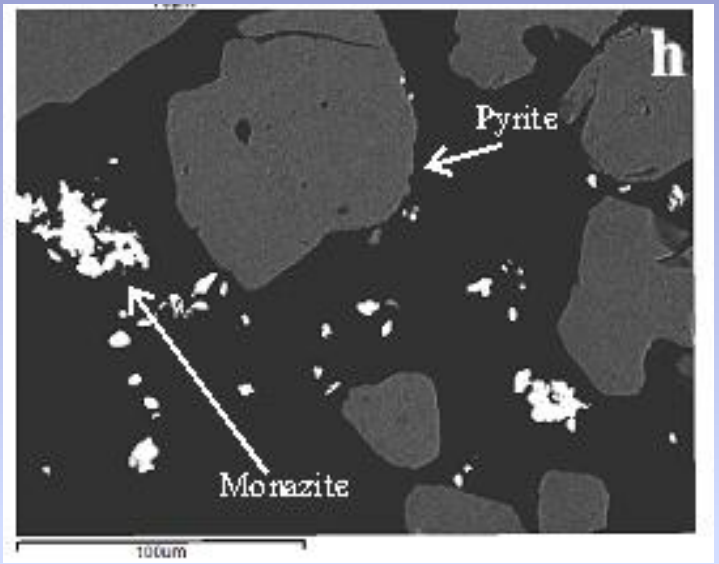
BRIGUS GOLD: Black Fox Contact-147 Zone Deposits

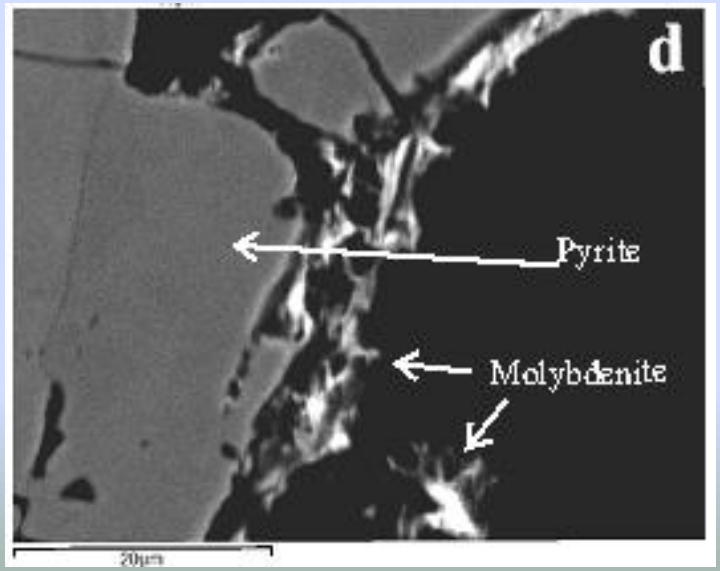
- Au coincident with carbonate - K+Na altered volcanic-sedimentary rocks near a syenitic intrusion.
- Vein and disseminated ore at deformed lithological boundaries related to PDFZ.
- Drill indicated resource 6.3 Mt @ 4g/t (e.g. 5.9 g/56.7 m, 26 g/15.5 m).

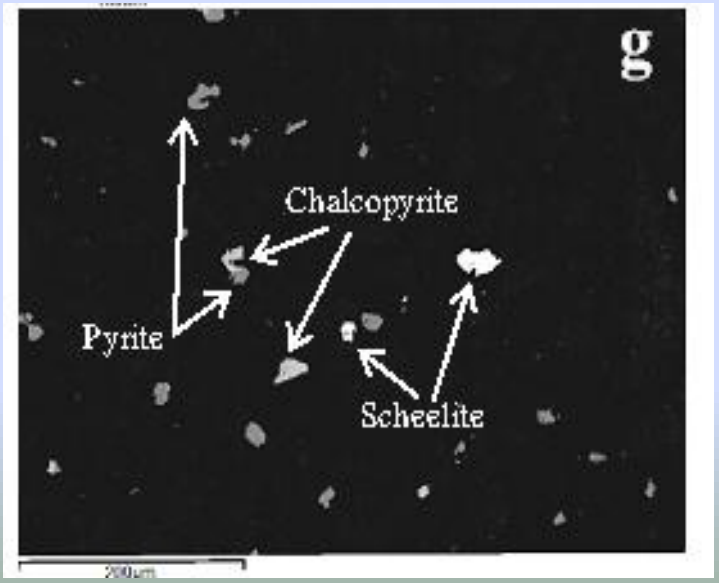


SEM-BSE images showing association of Au-W-Mo-LREE…. This is part of the syenite association in this and other areas. Also have locally abundant Hmt.

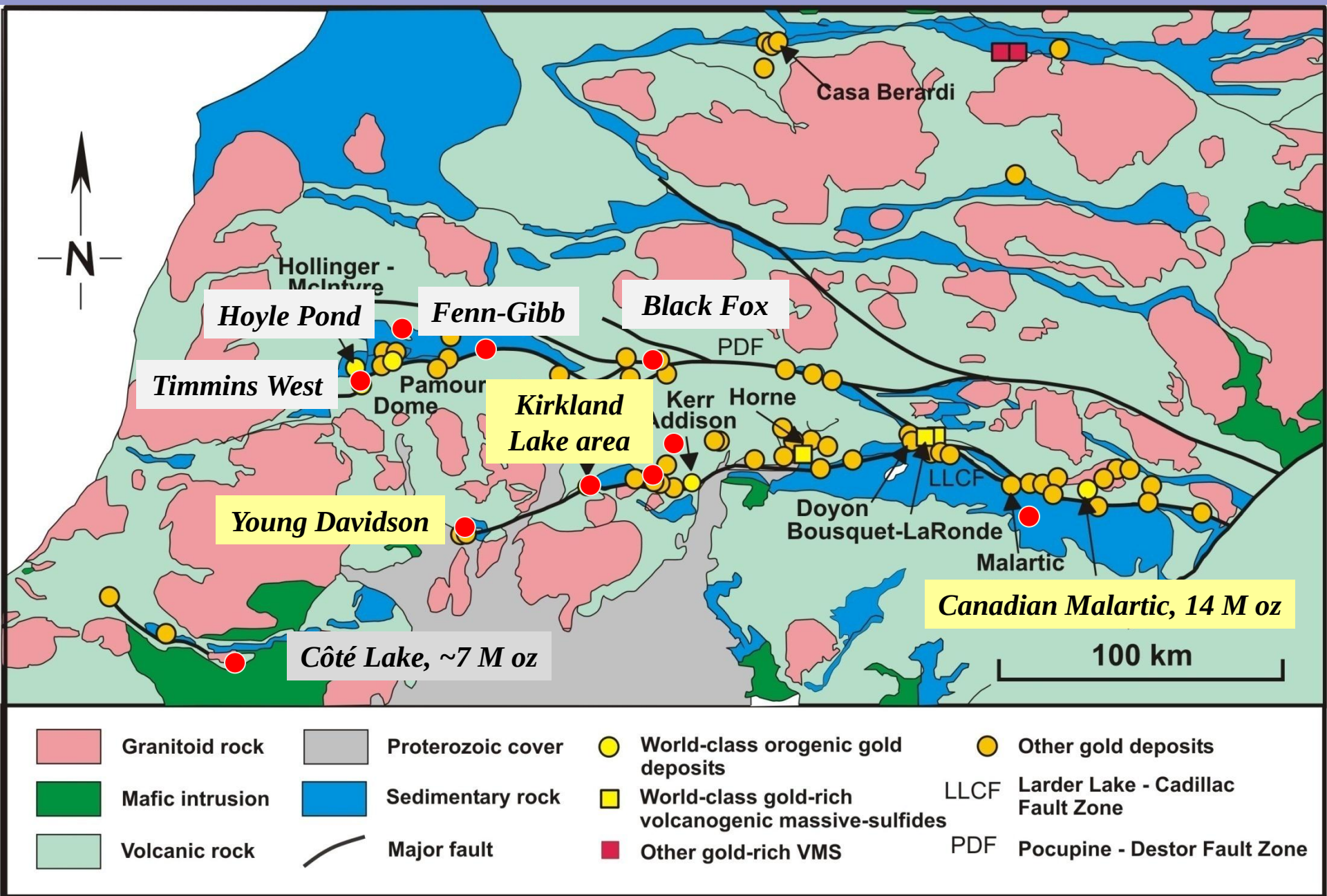




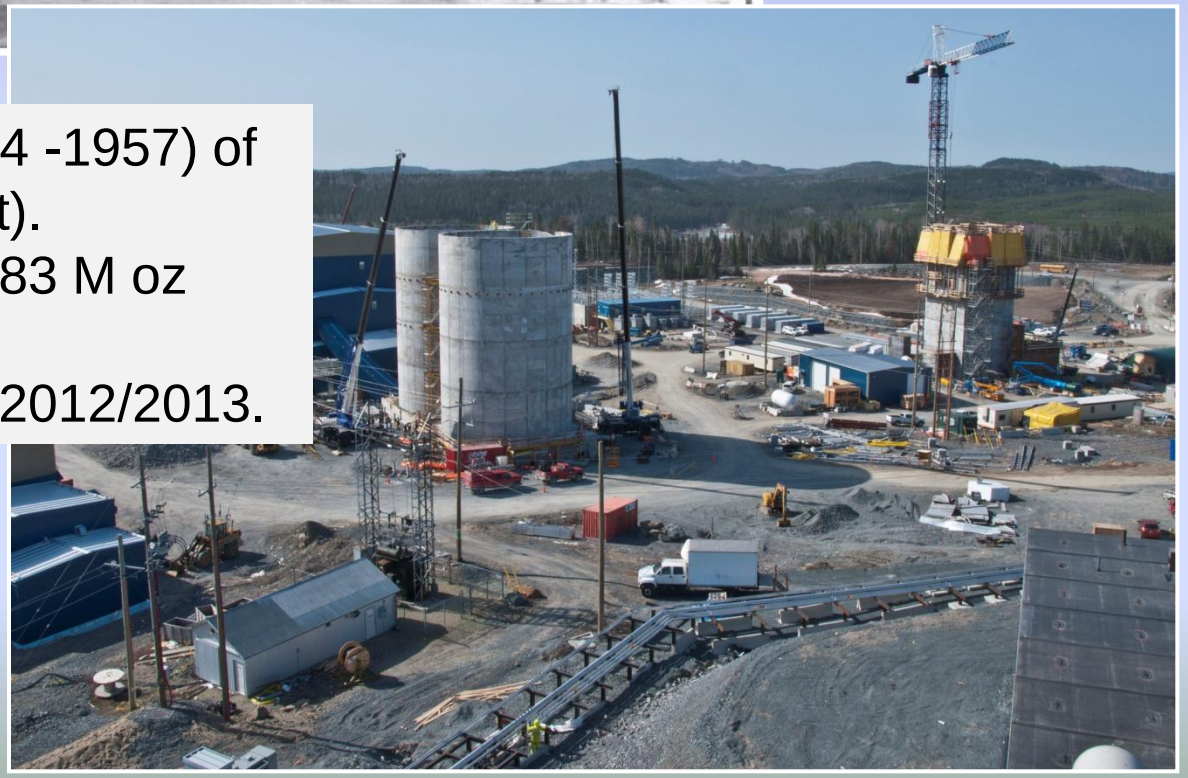




Gold Deposits along the Larder Lake-Cadillac Fault Zone

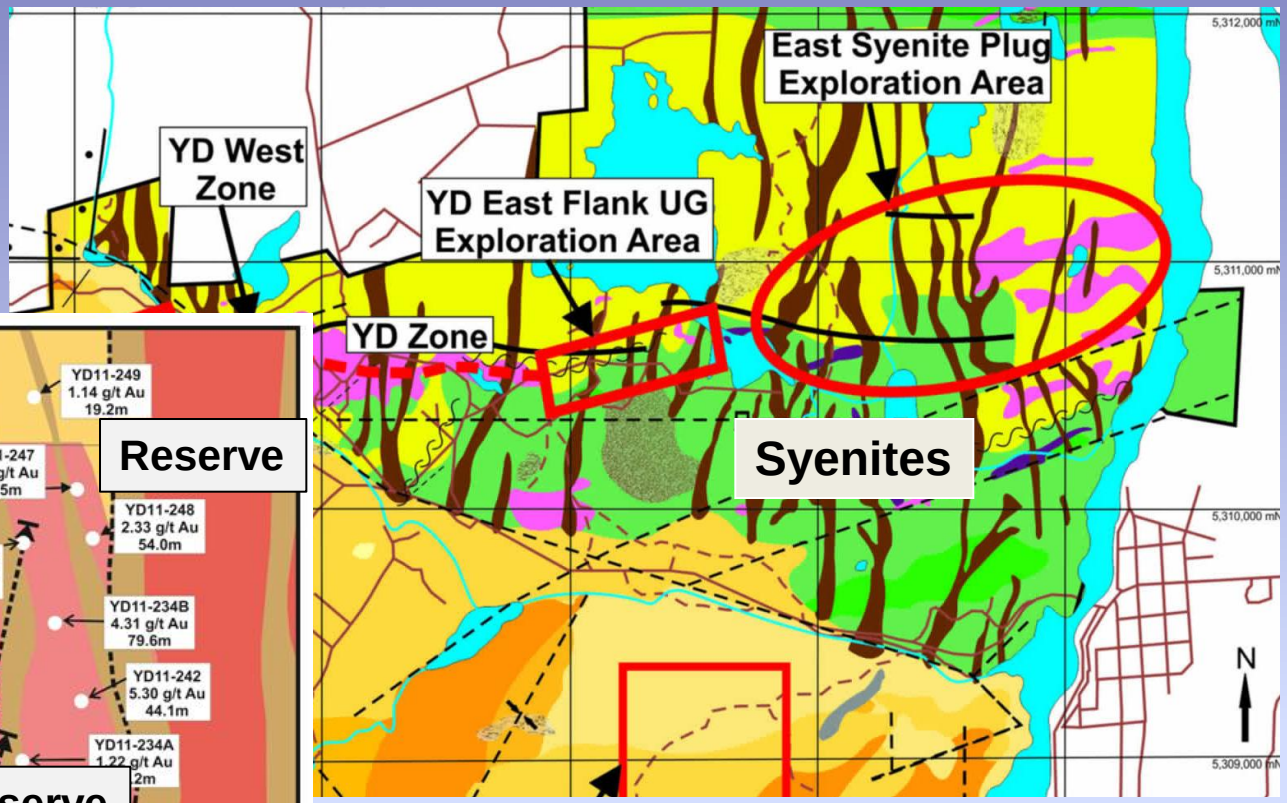


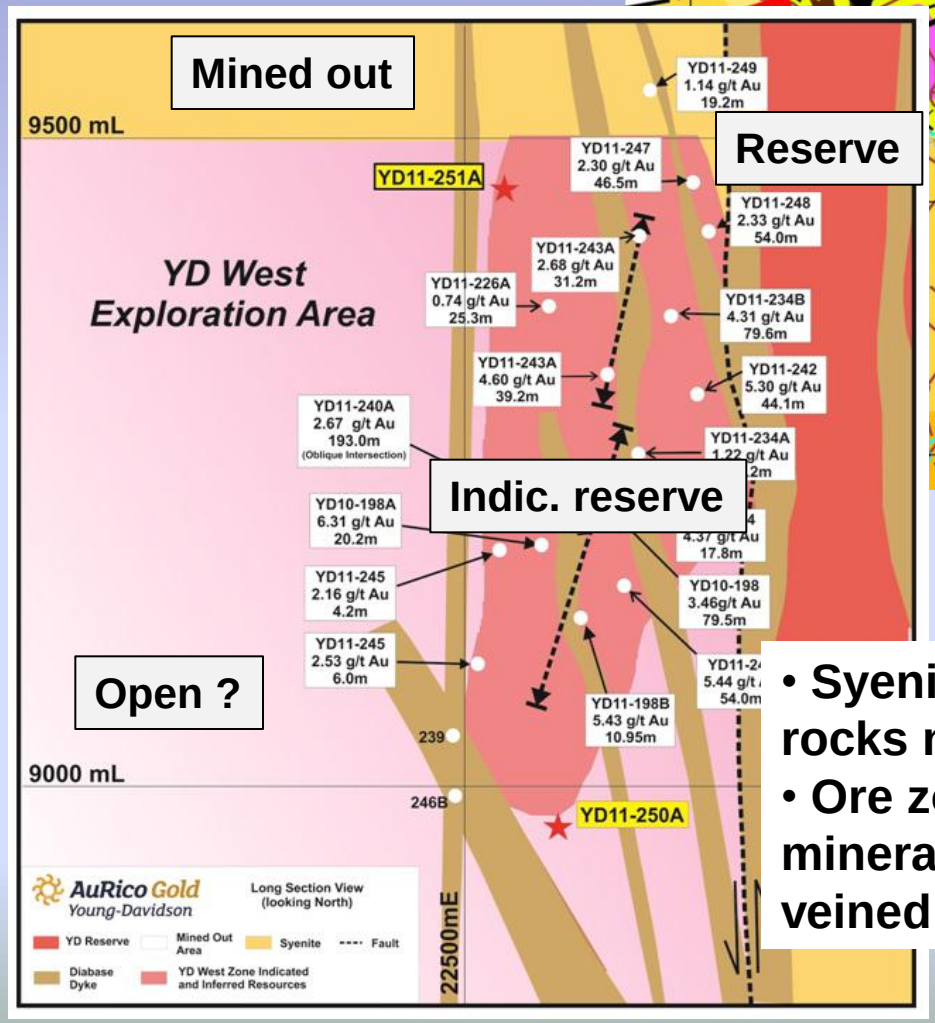
AuRico GOLD: YOUNG DAVIDSON DEPOSIT



- Historical production (1934 -1957) of 0.97 M oz (9.7 Mt @ 3.3 g/t).
- Current reserves about 3.83 M oz (open at depth).
- Production to commence 2012/2013.

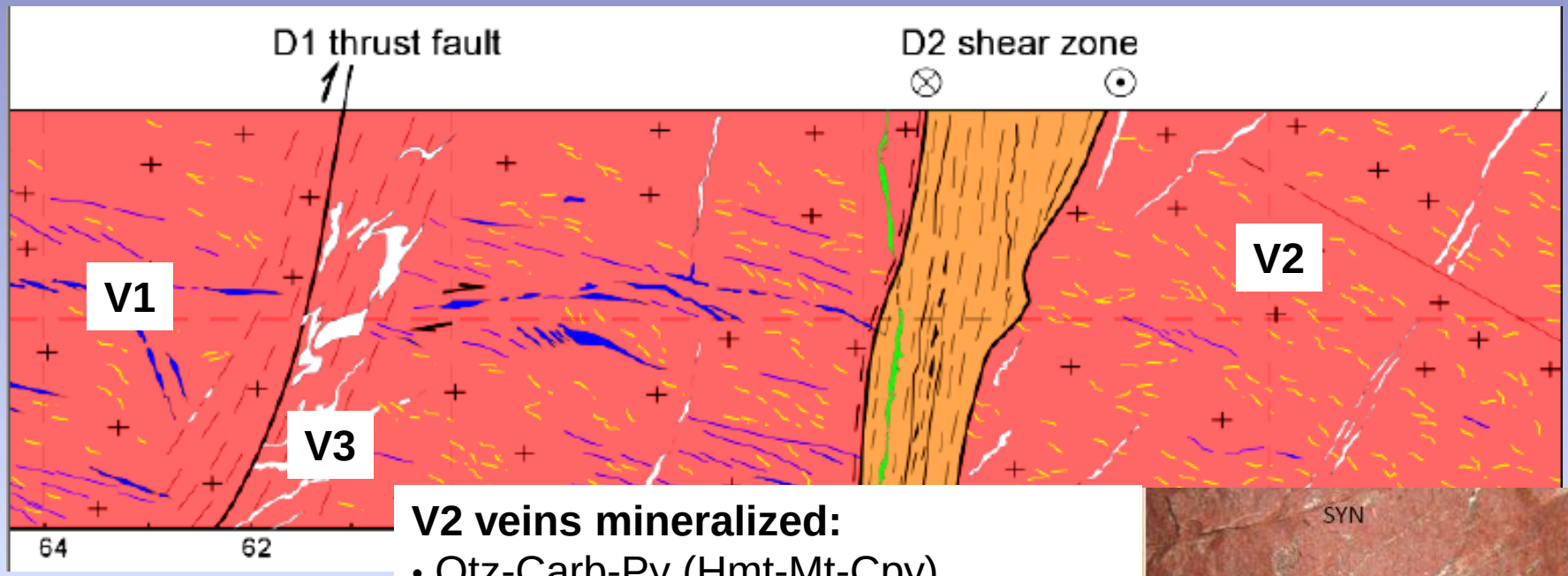
Facing N





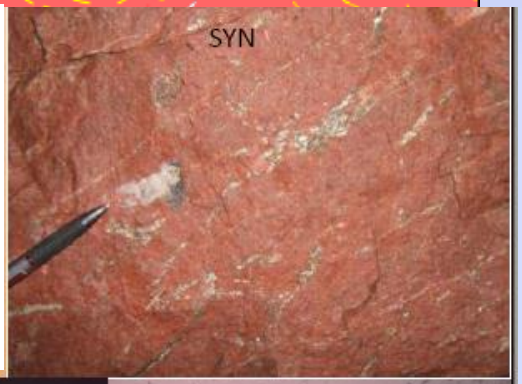
- Syenite sheets intrude TM Group sedimentary rocks north of a suite of older volcanic rocks.
- Ore zone (YD West and East) is a 30 m thick mineralized section of altered (K, Hmt) and veined (quartz) syenite.

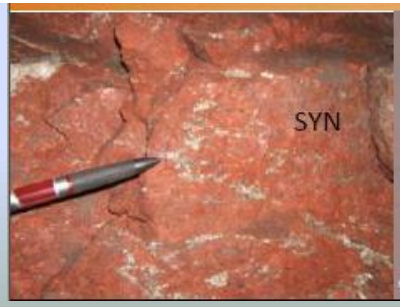
Underground face map looking N (Linnen et al., 2012):

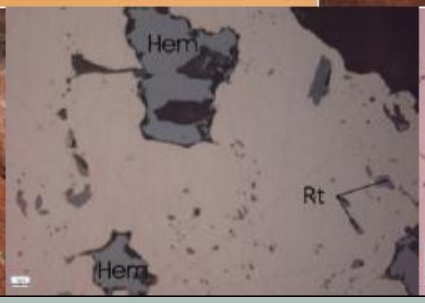


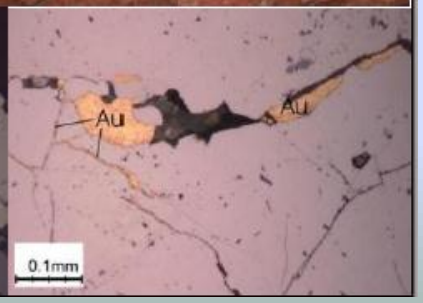
V2 veins mineralized:

- Qtz-Carb-Py (Hmt-Mt-Cpy).
- Au as inclusions in pyrite.
- High T (400°C) magmatic-derived fluids.
- **V1, V3 are barren stages!!!**



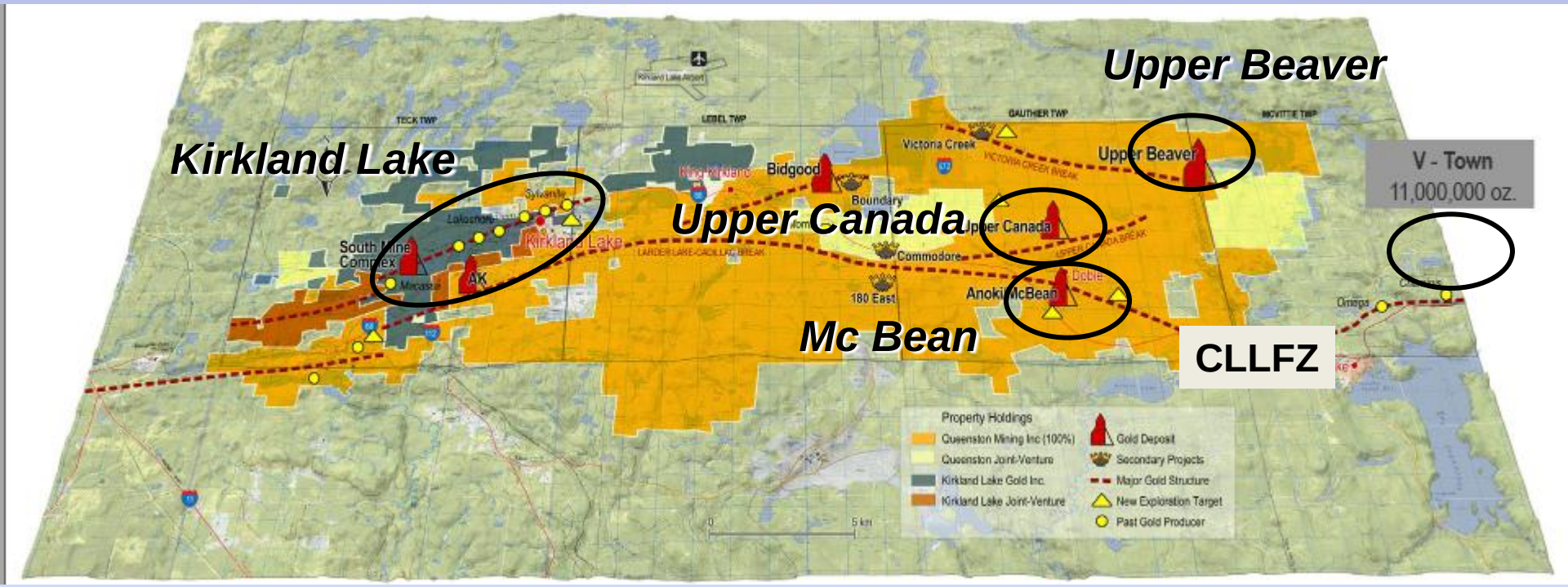




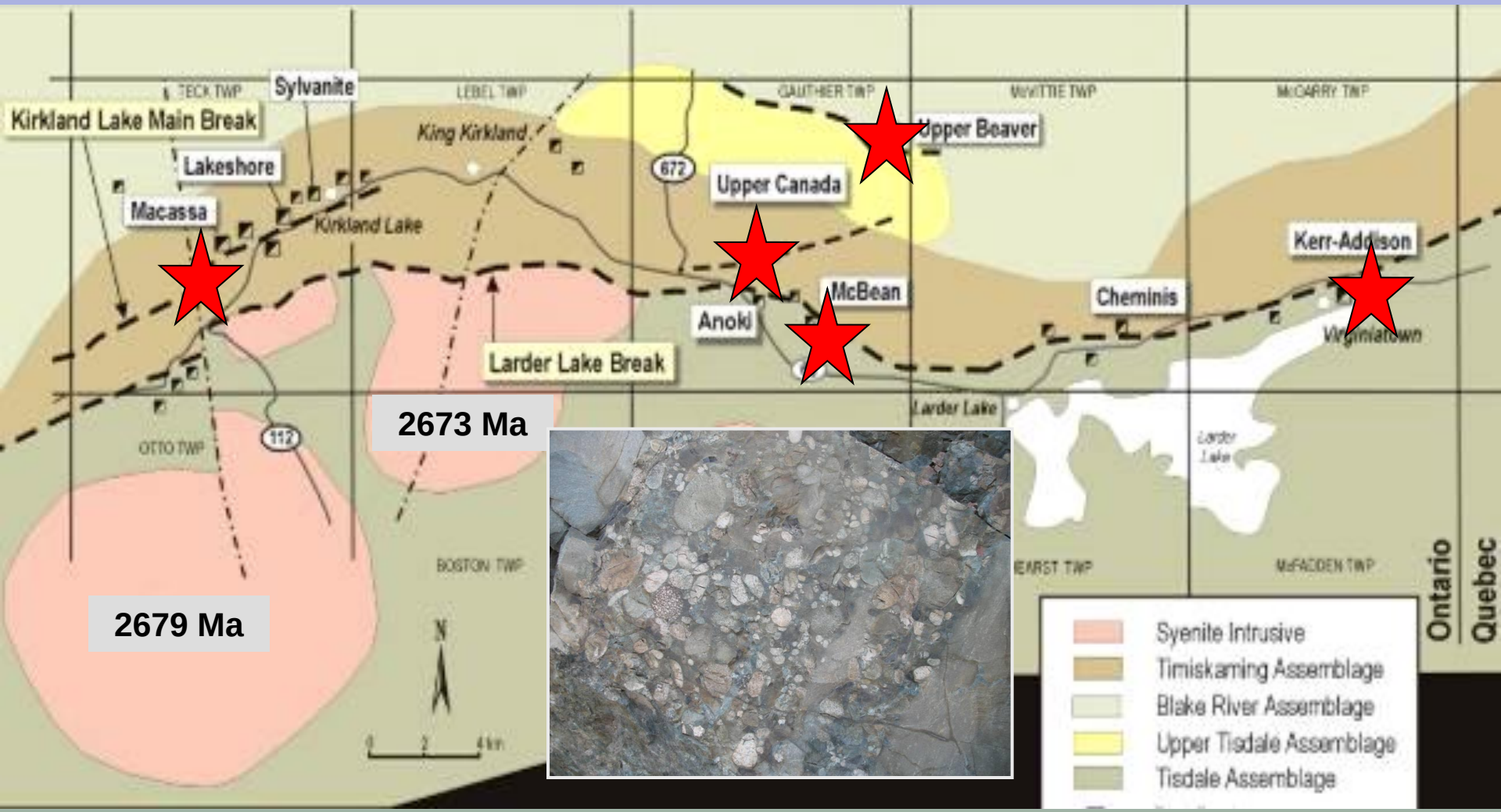


KIRKLAND LAKE GOLD CAMP
(45 M oz historical production)

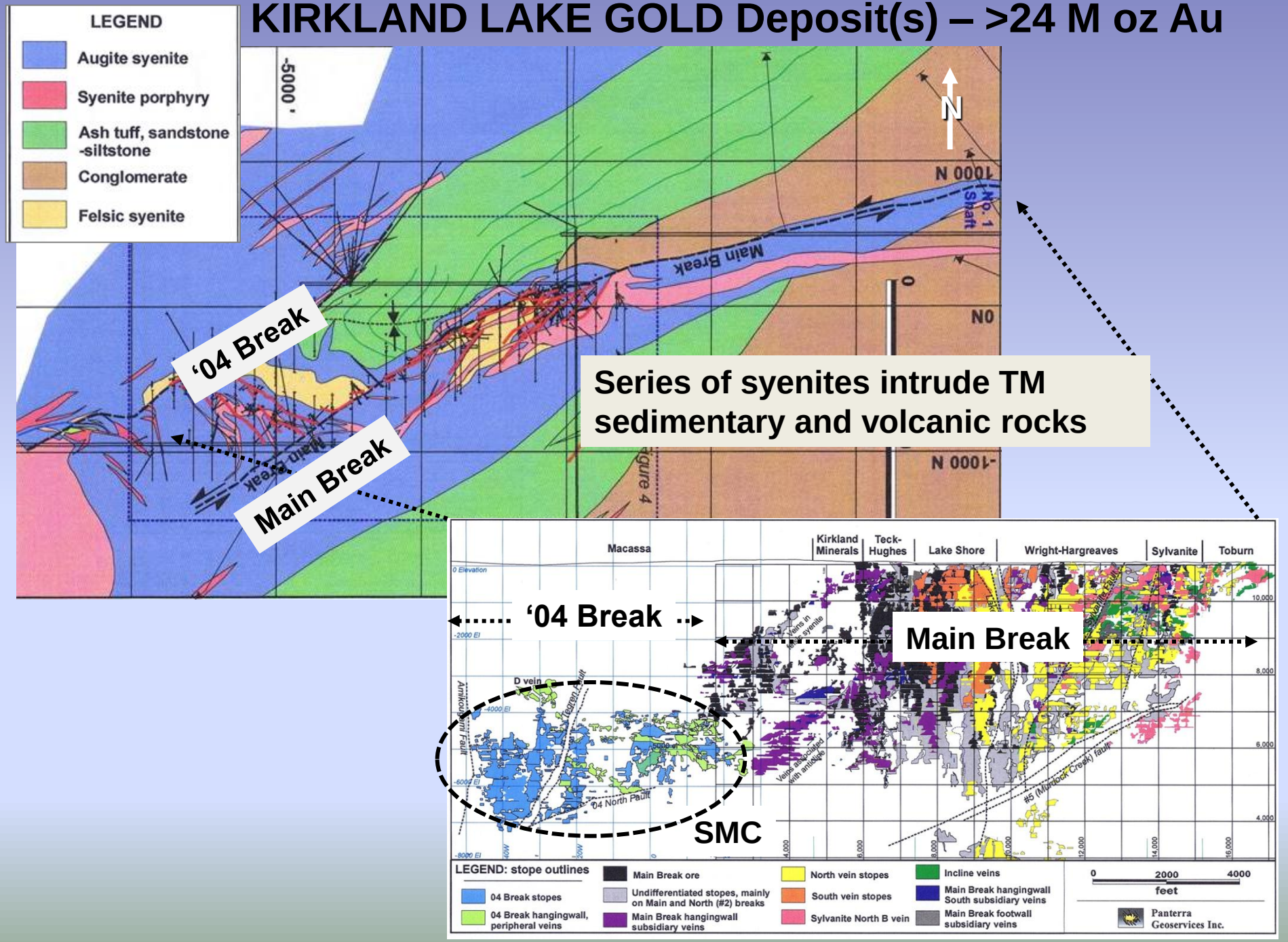
Mineralization occurs on several structures (Main, ’04 breaks, etc.)



- Au mineralization is along main or secondary structures.
- Au occurs within *Timiskaming sedimentary and volcanic rocks and rarely in the older volcanic package.*
- Deposits record post-mineralization deformation.
- Vein- and disseminated-type mineralization.



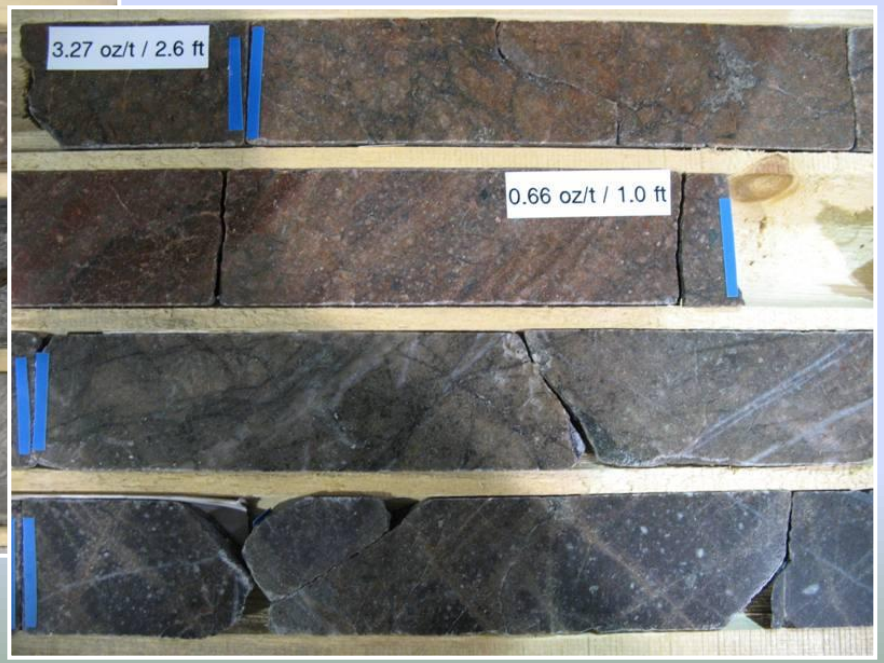
KIRKLAND LAKE GOLD Deposit(s) – >24 M oz Au



Gold occurs in the syenites as:

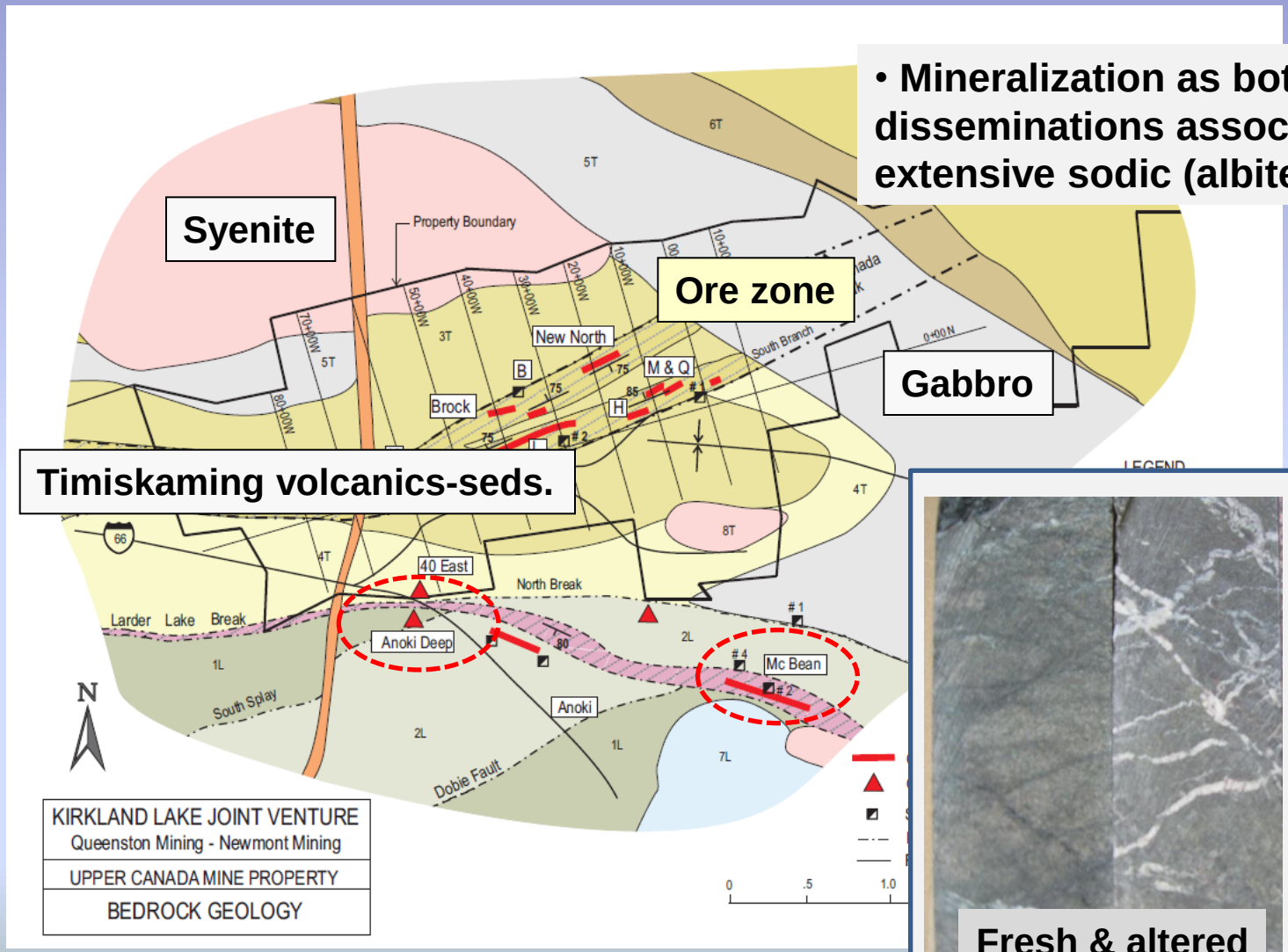
- Quartz-(carbonate) veins in fault/shear zones (Main and ‘04 Breaks)

- Disseminations with pyrite-tellurides (South Mine Complex)



QUEENSTON MINING INC.: Upper Canada Deposit (6.8 Mt @ 3 g/t, 0.77 M oz); also Mc Bean and Anoki zones

- Mineralization as both veins and disseminations associated with extensive sodic (albite) altered zones.

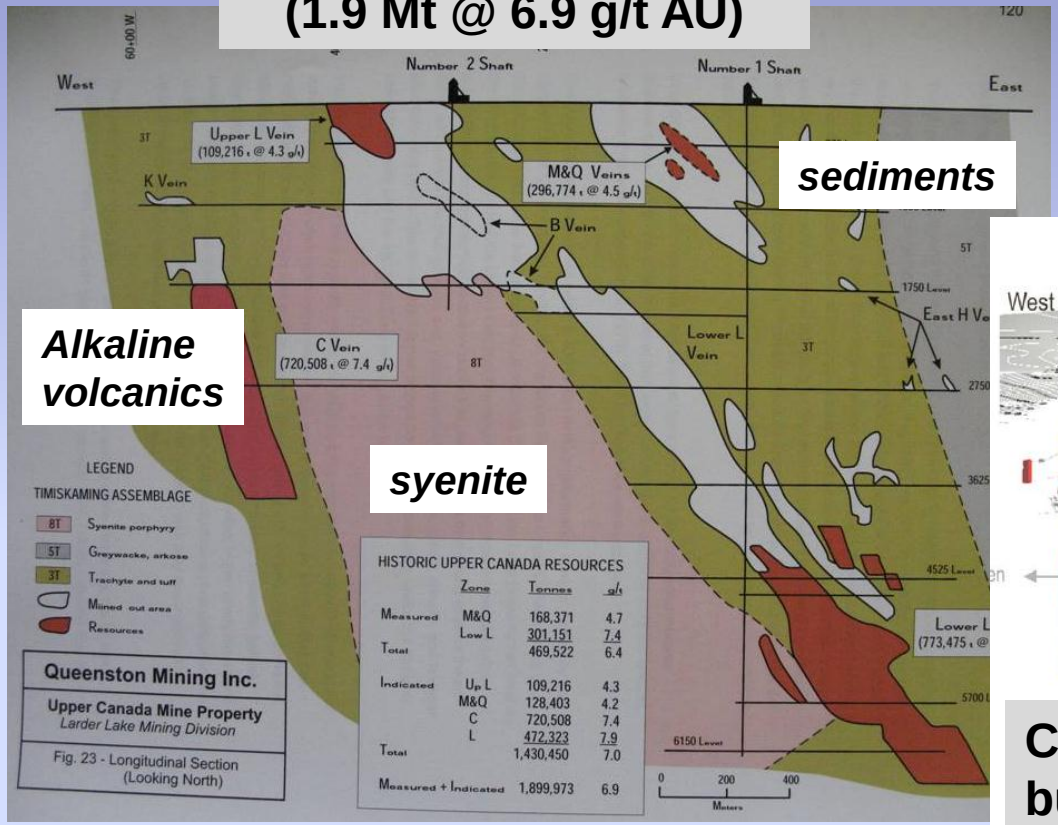


Fresh & altered sediment


Fresh & altered syenite

QUEENSTON MINING INC.: Upper Canada Deposit

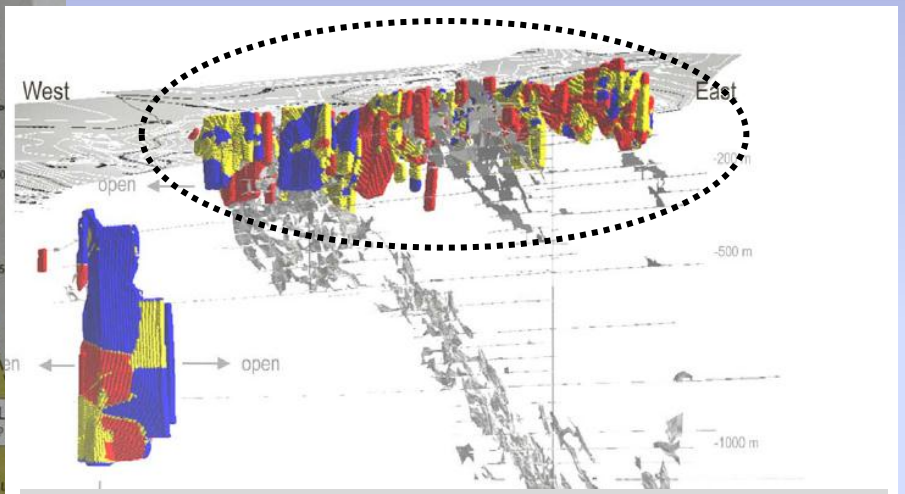
Historical vein workings (1.9 Mt @ 6.9 g/t AU)



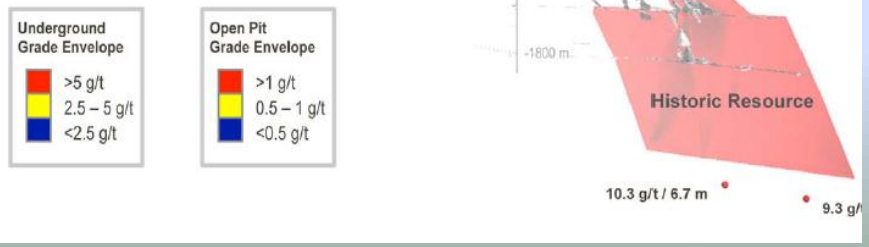
sediments

Alkaline volcanics

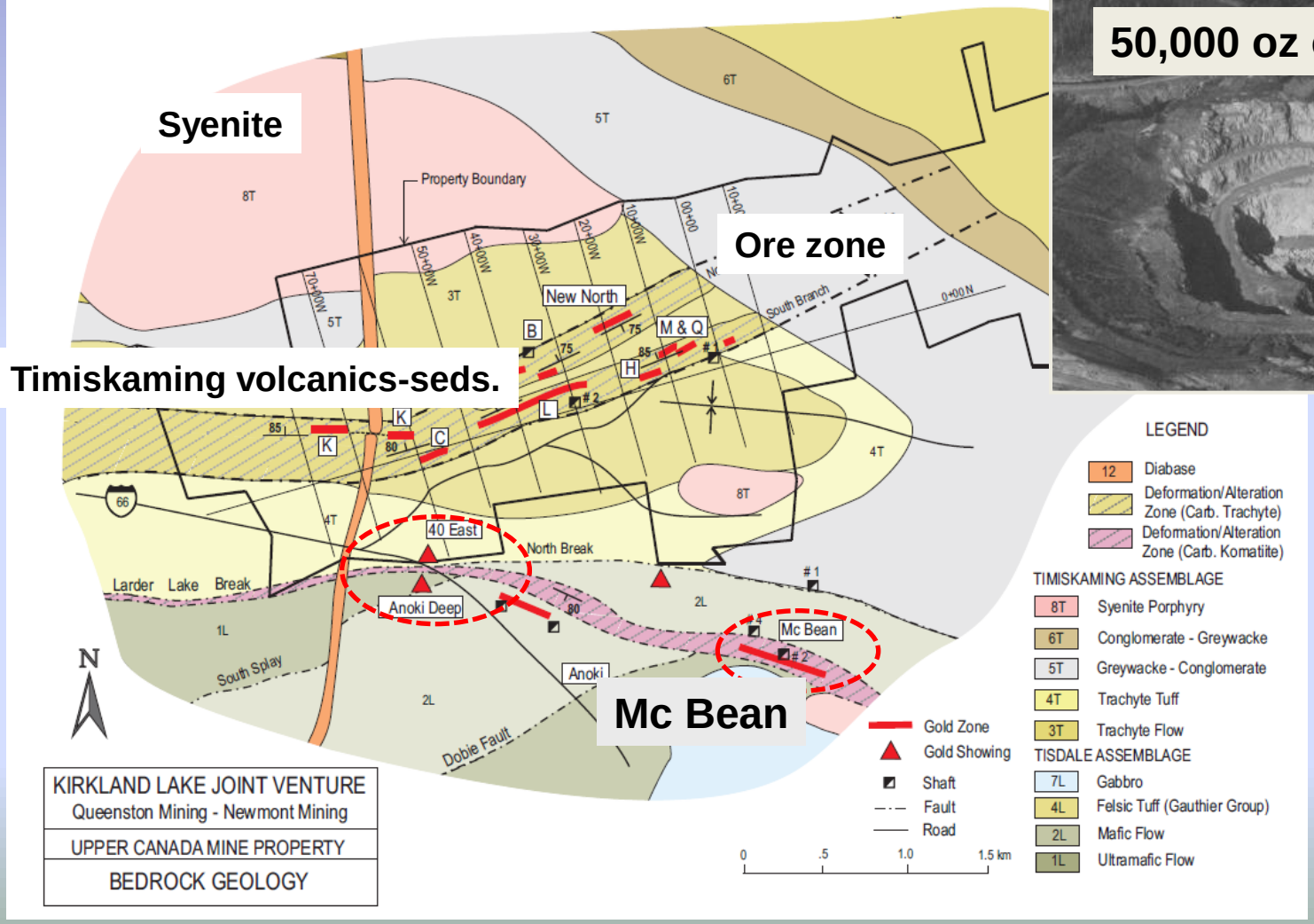
syenite

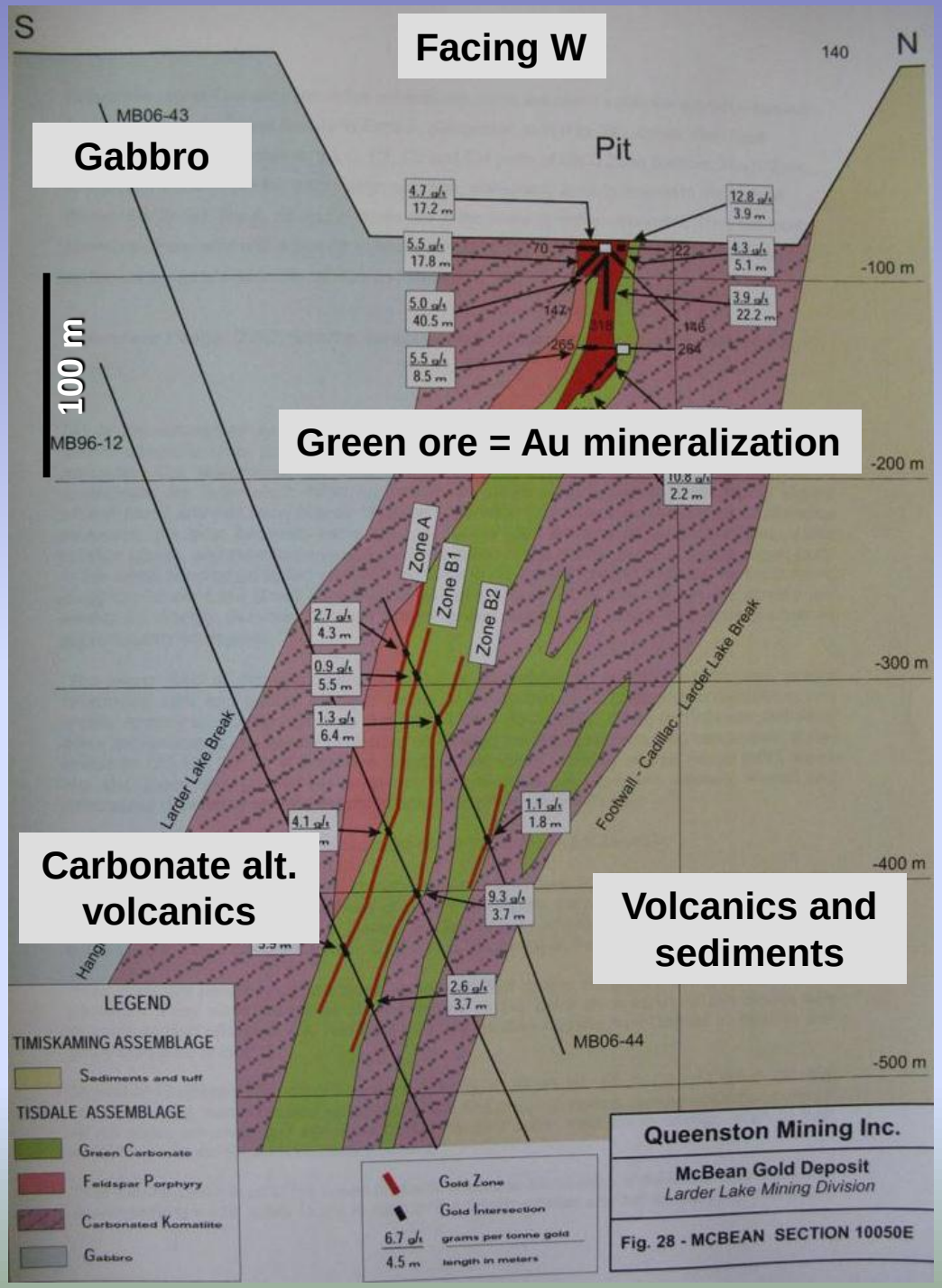


Current open pit model: looking to bulk mine a low-grade reserve (6.8 Mt @ 3 g/t).

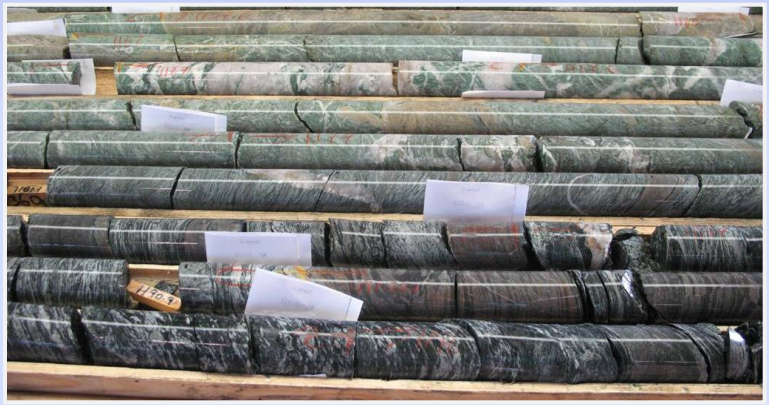


QUEENSTON MINING INC.:
Mc Bean Deposit (1.9 Mt @ 4.7 g/t)




Facing W
S
N
140
MB06-43
Pit
Gabbro
100 m
MB96-12
-100 m
-200 m
-300 m
-400 m
-500 m
Green ore = Au mineralization
Zone A
Zone B1
Zone B2
Larder Lake Break
Footwall - Cadillac - Larder Lake Break
Carbonate alt. volcanics
Volcanics and sediments
MB06-44
LEGEND
TIMISKAMING ASSEMBLAGE
Sediments and tuff
TISDALE ASSEMBLAGE
Green Carbonate
Feldspar Porphyry
Carbonated Komatiite
Gabbro
Gold Zone
Gold Intersection
6.7 g/t grams per tonne gold
4.5 m length in meters
Queenston Mining Inc.
McBean Gold Deposit
Larder Lake Mining Division
Fig. 28 - MCBEAN SECTION 10050E

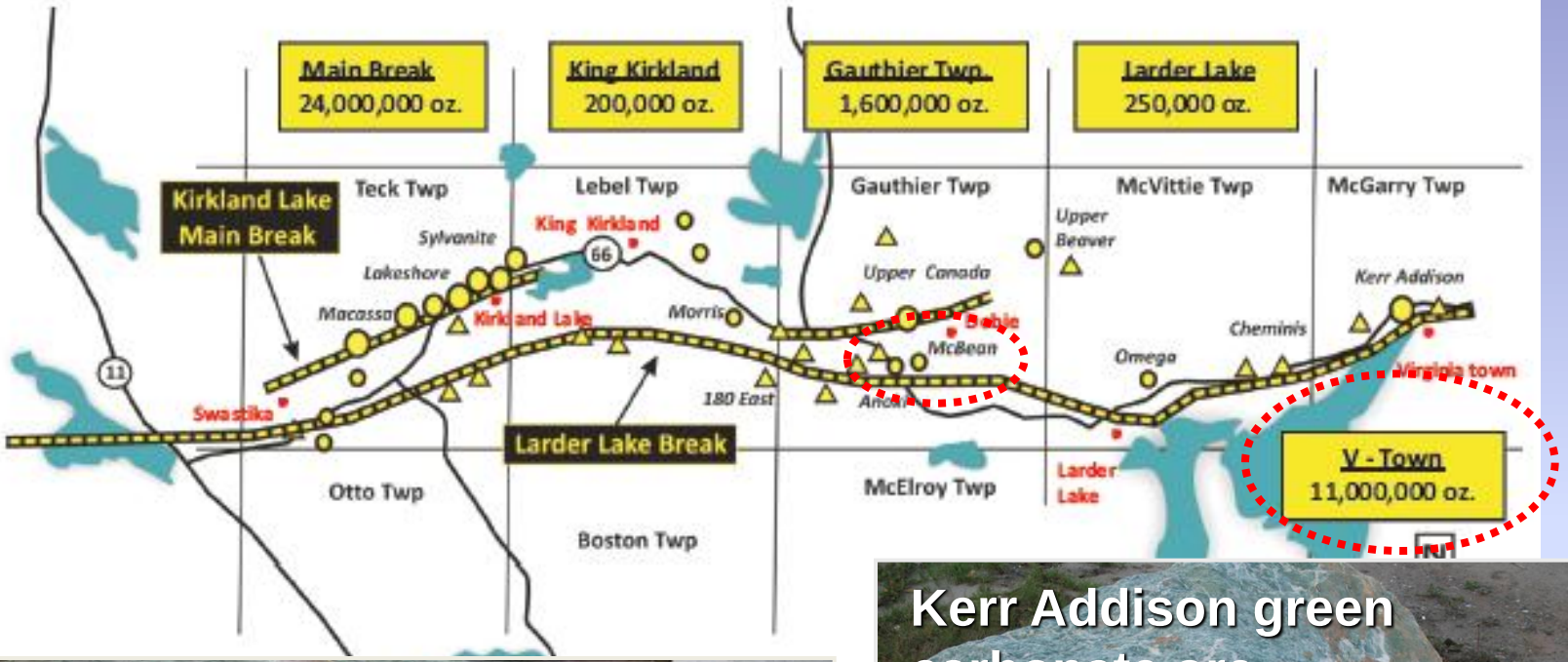

Altered syenite porphyry



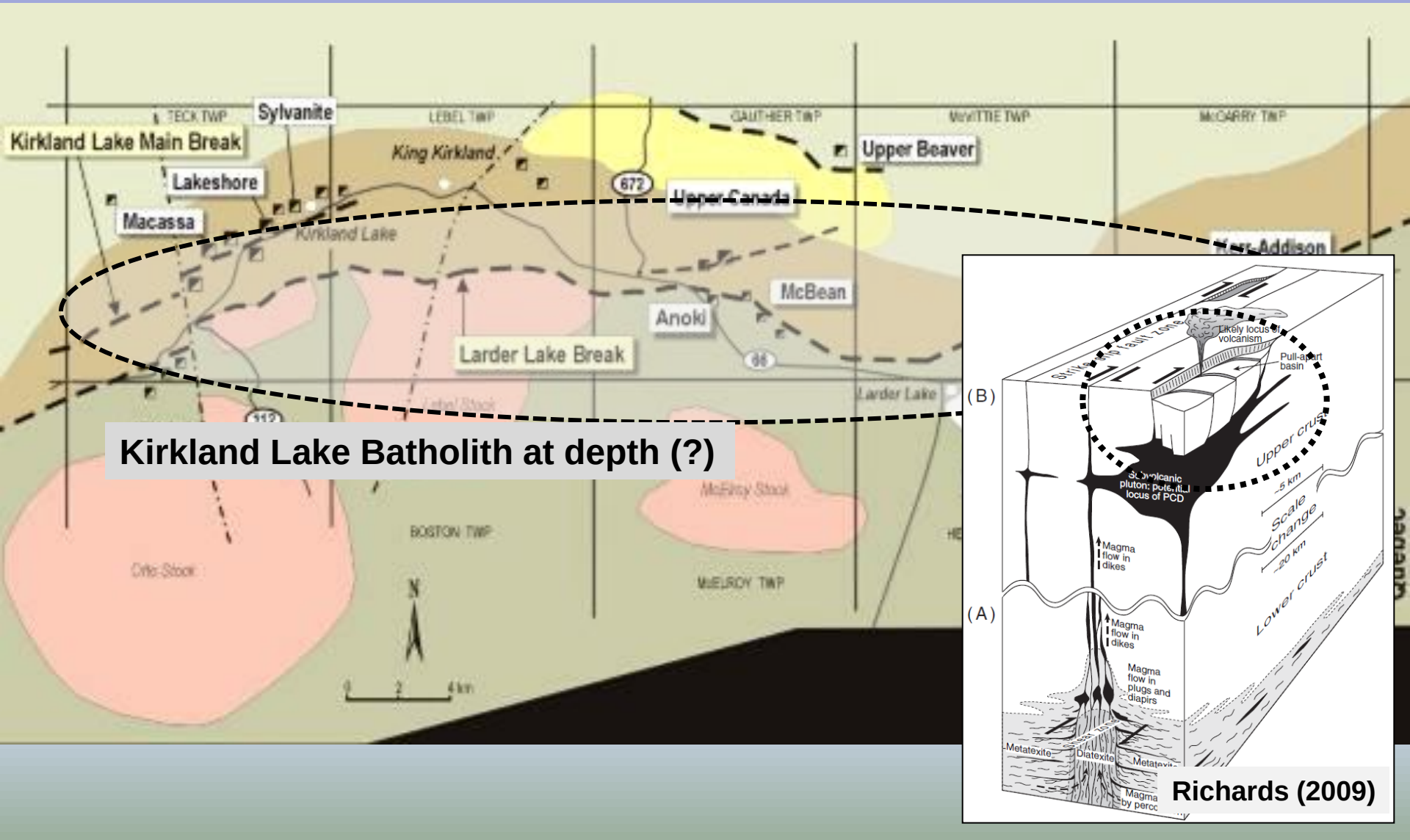

Green carbonate ore

Kirkland Lake Gold Camp, Ontario

100 years of production from 25 mines (40 M oz - 100 Mt @ 13 g/t)



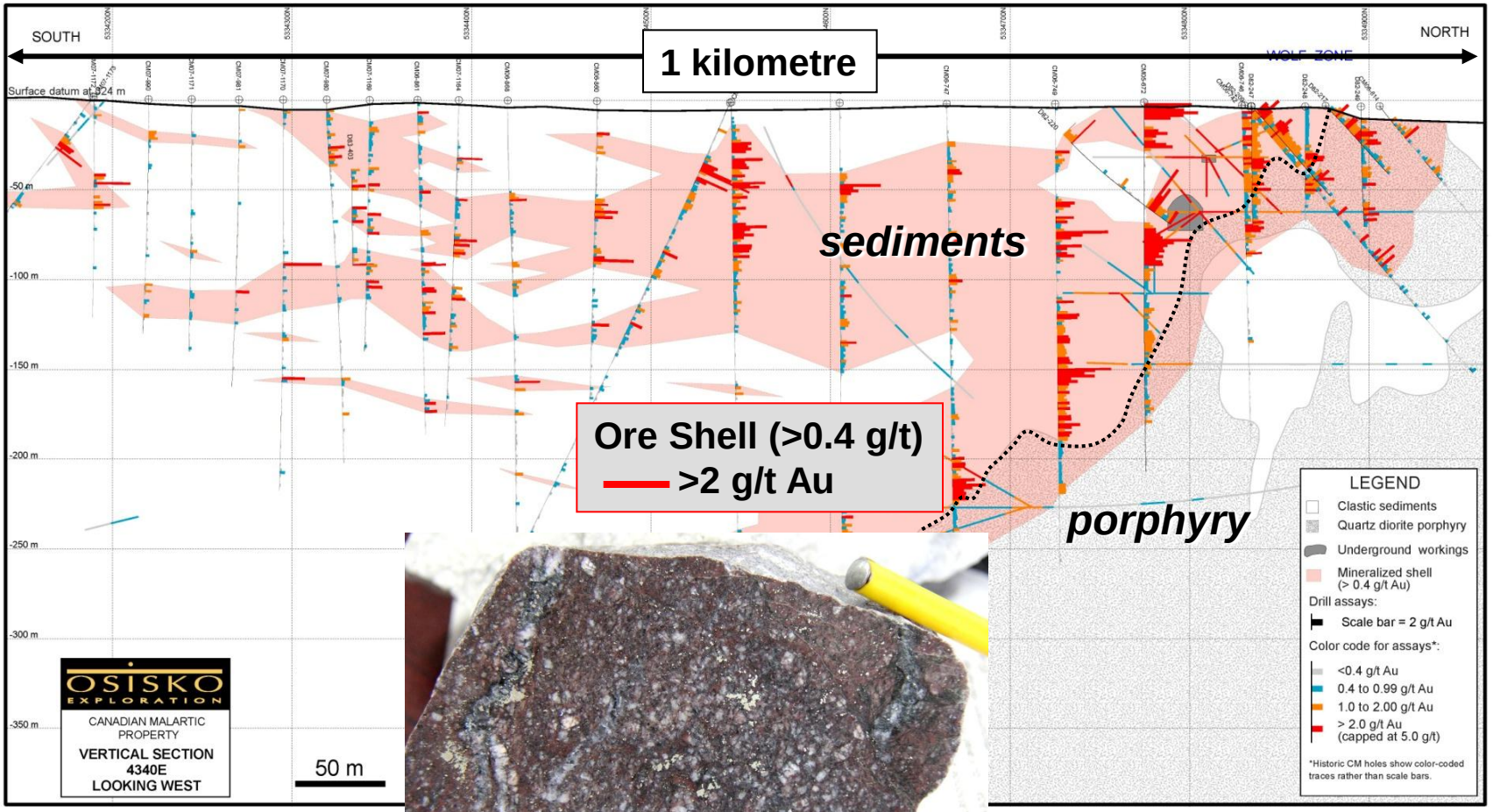
Kirkland Lake Gold Deposit(s) –What is the source of fluids and Au along this 40 km trend?



OSISKO'S Canadian Malartic Deposit (425 Mt @ ~1 g/t, ~14 M oz):

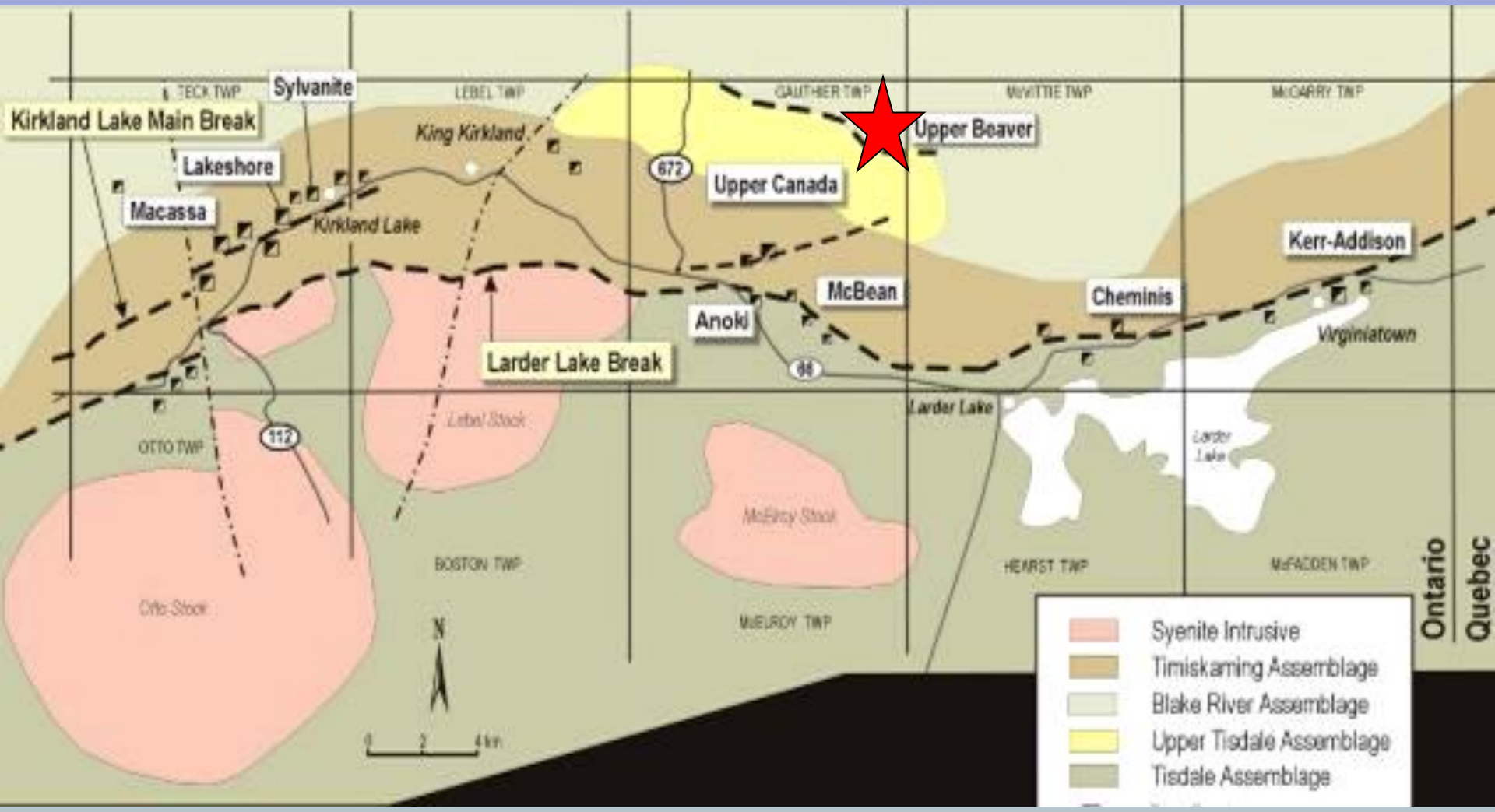
- Near the Cadillac Fault Zone; historical workings as quartz-carbonate veins.
- New ore zones in Pontiac Group metasedimentary rocks cut by qf porphyry dykes with potassic alteration and disseminated pyrite.
- Production (Q1, 2012) at 50,000 t/day.

Facing West



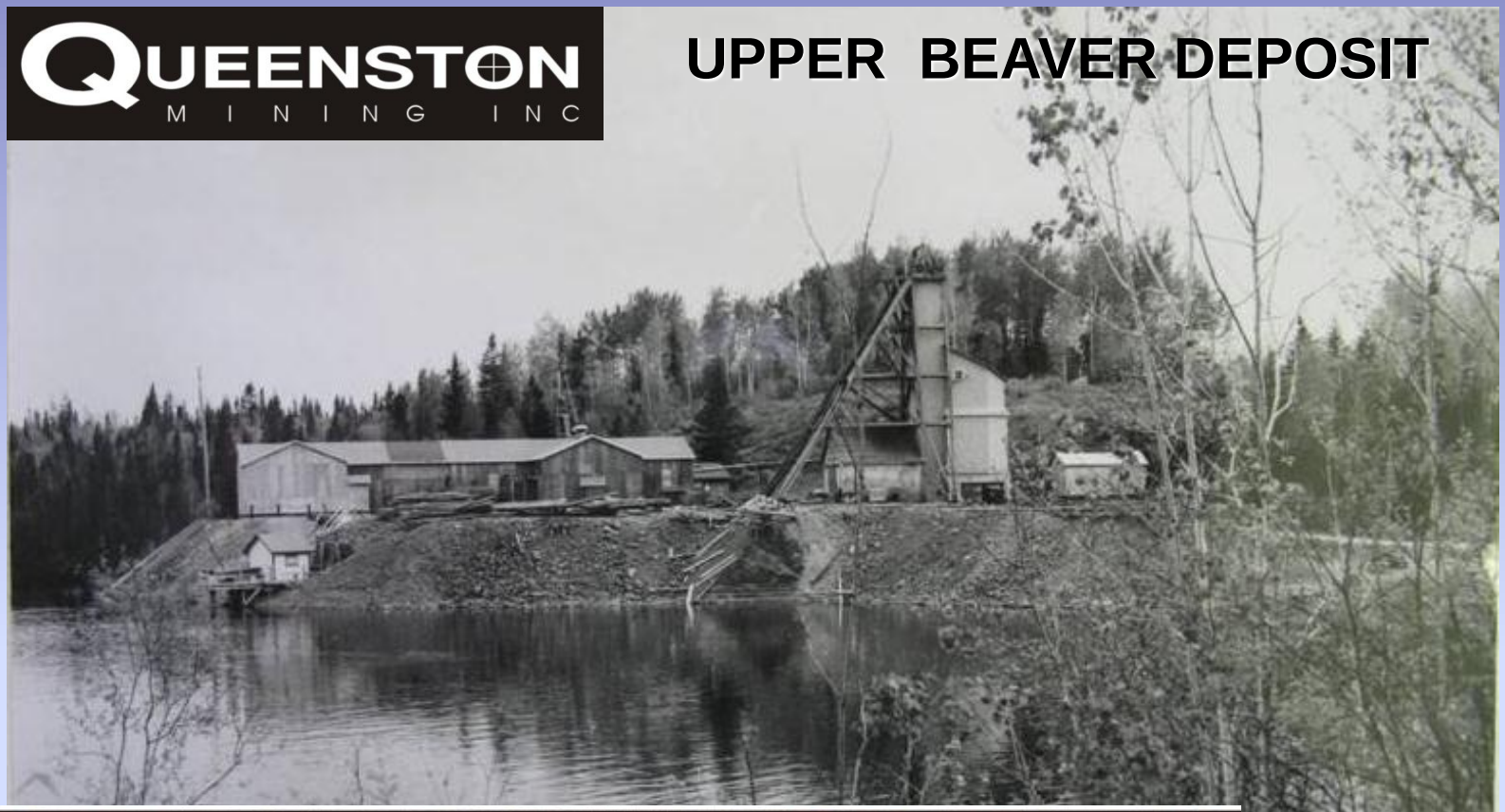
Porphyry with disseminated pyrite and biotite alteration.

Upper Beaver Deposit



QUEENSTON MINING INC

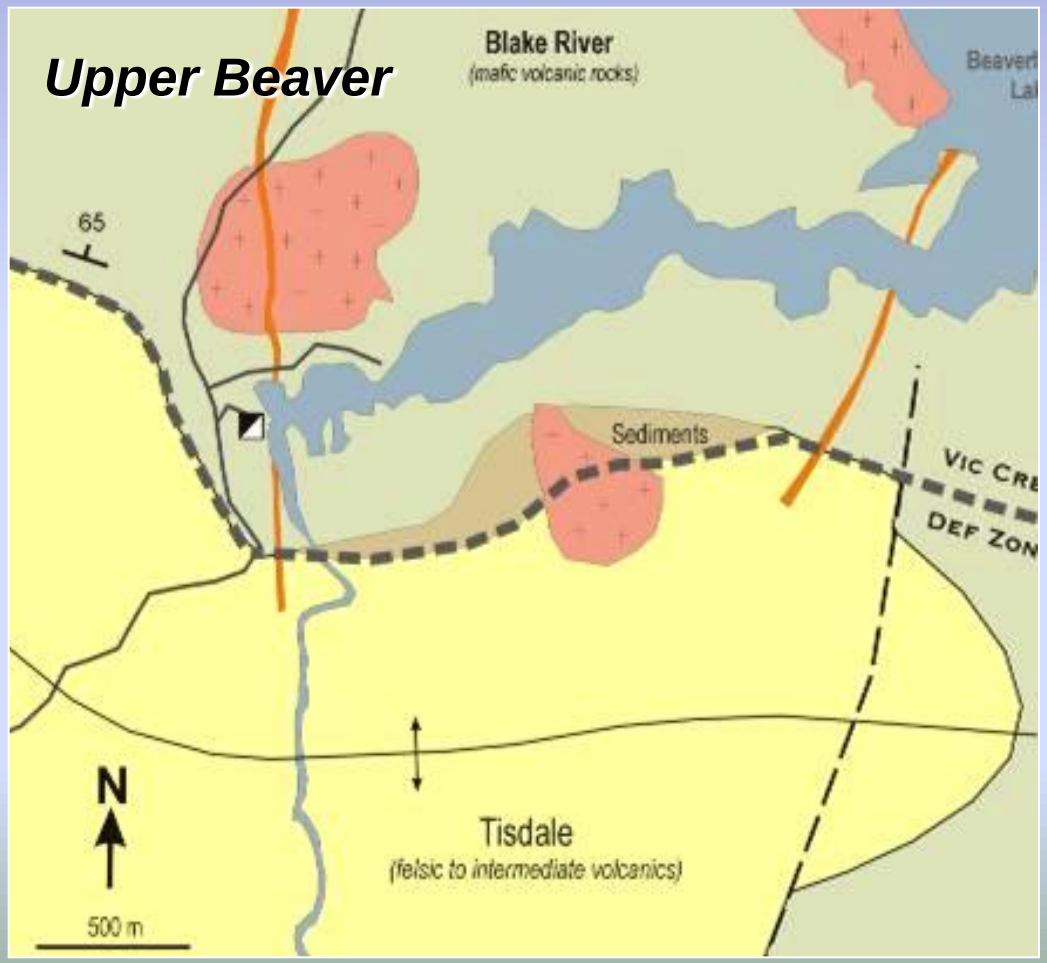
UPPER BEAVER DEPOSIT

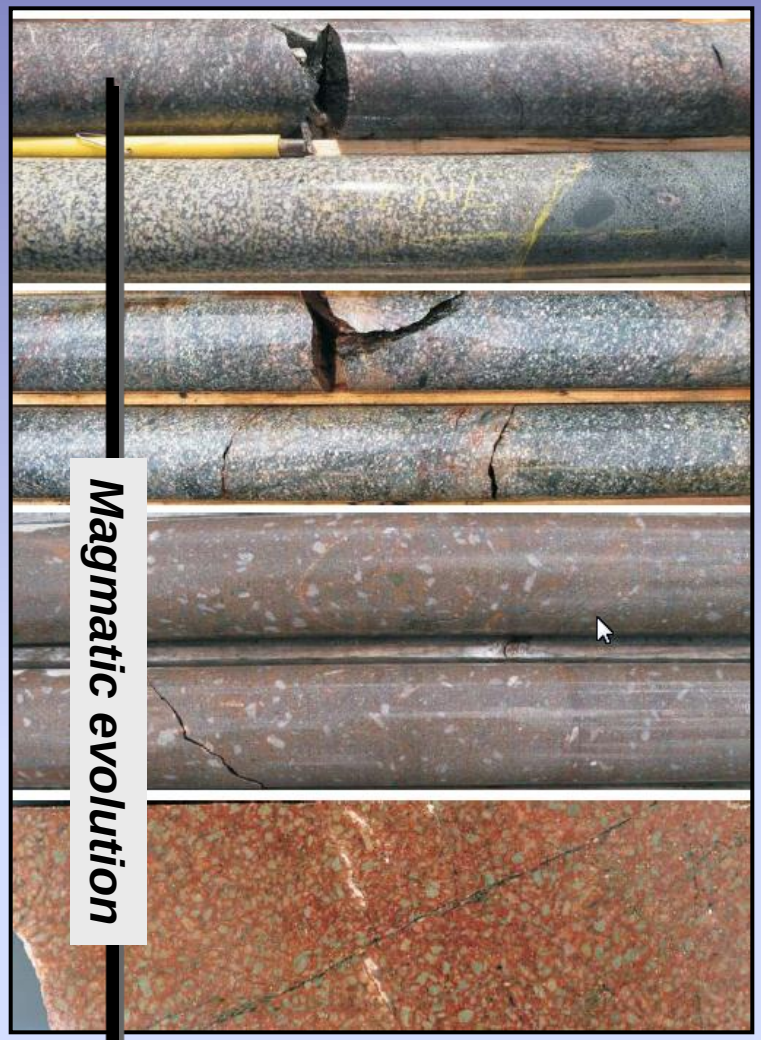


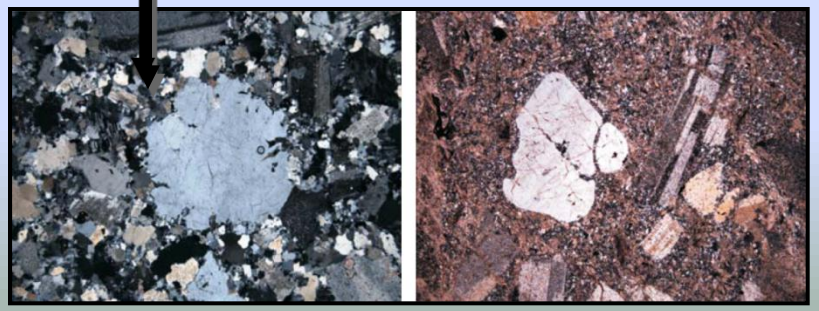
Historical: 0.77 Mt @ 7.7 g/t
Current: 6 Mt @ 7 g/t (1.5 M oz)

- **Mineralization hosted by a multi-phase amphibole syenite (2680 Ma) that evolves to a quartz syenite**

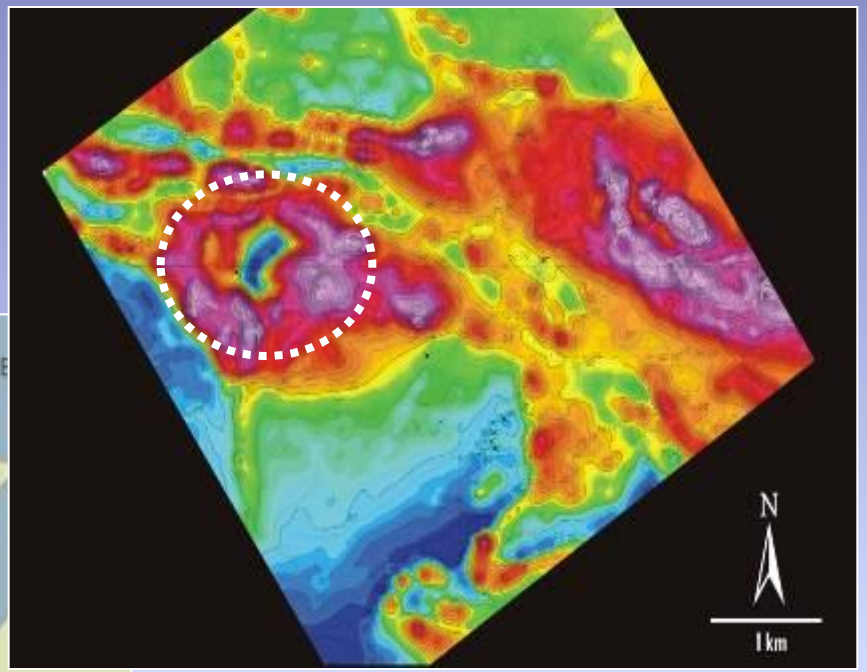
- **Located off the Main break, thus unusual!**

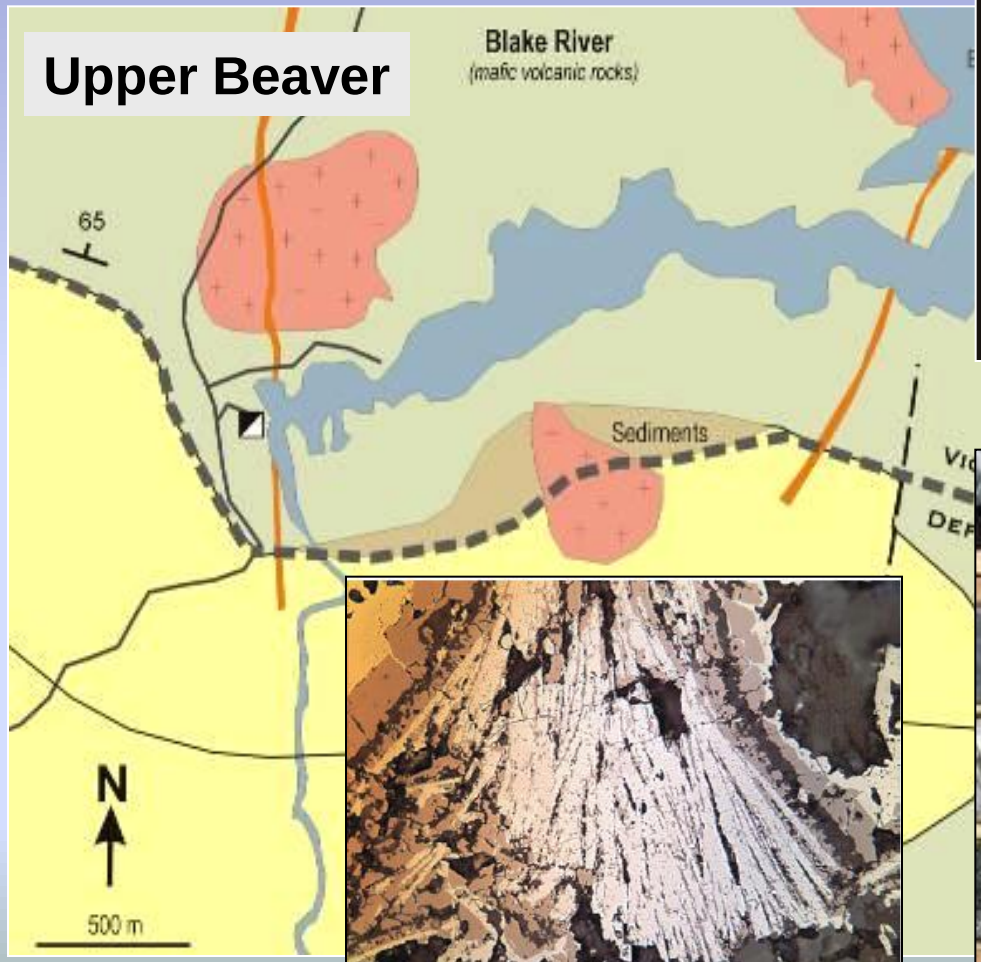




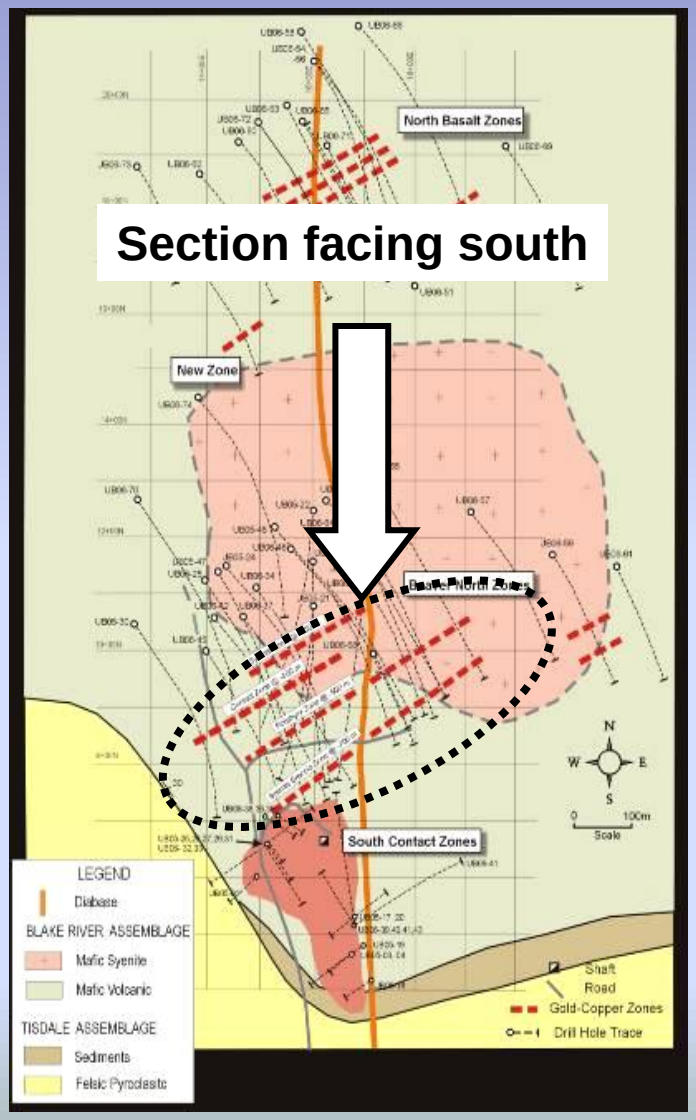


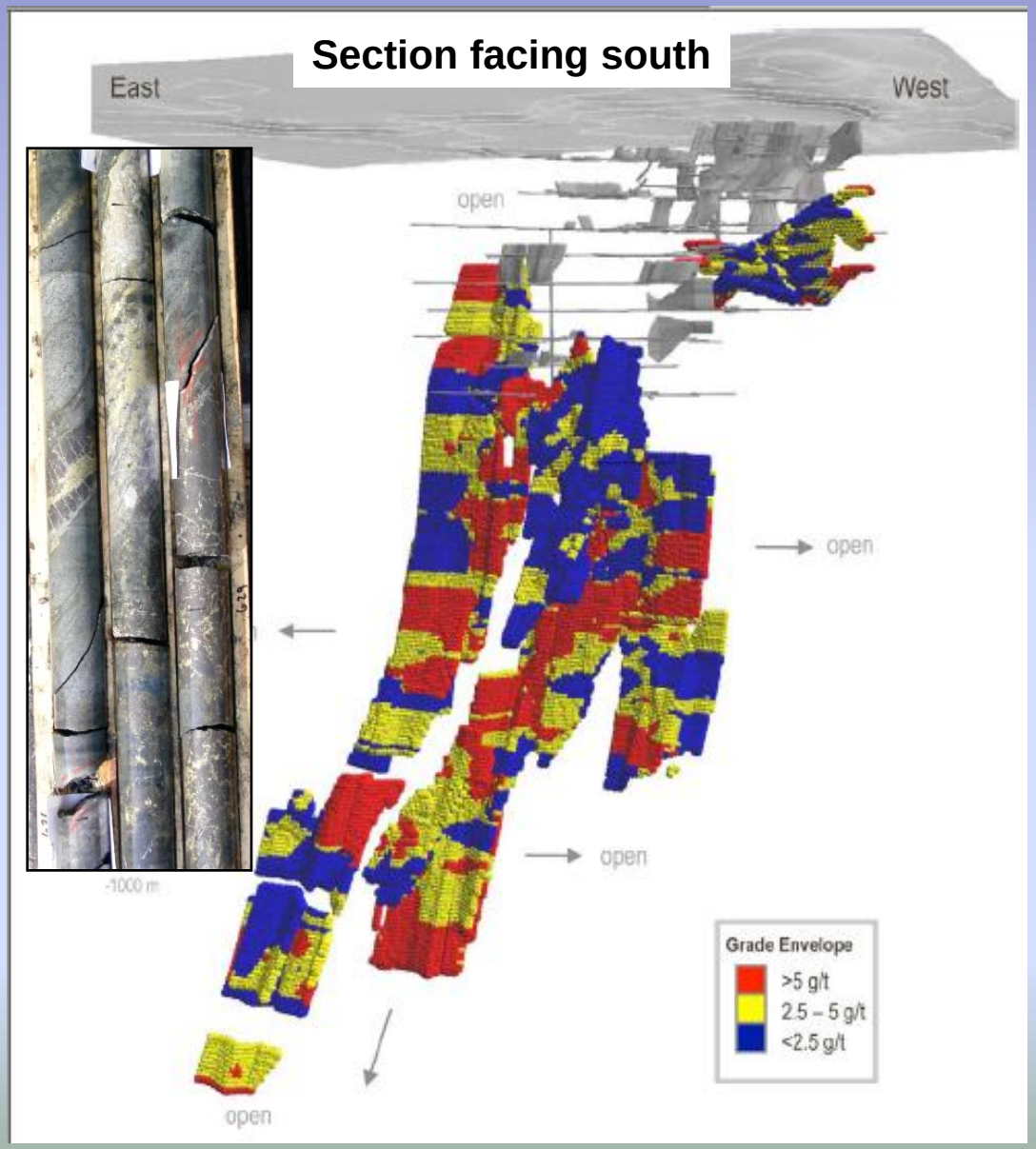
• **Deposit characterized by a magnetic anomaly due to pervasive Mt alteration, after early Hmt, related to remobilization of Fe from Fe-rich volcanic rocks.**

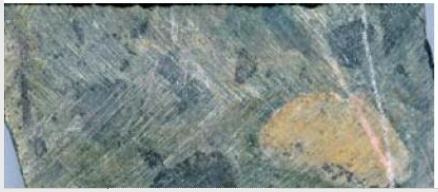


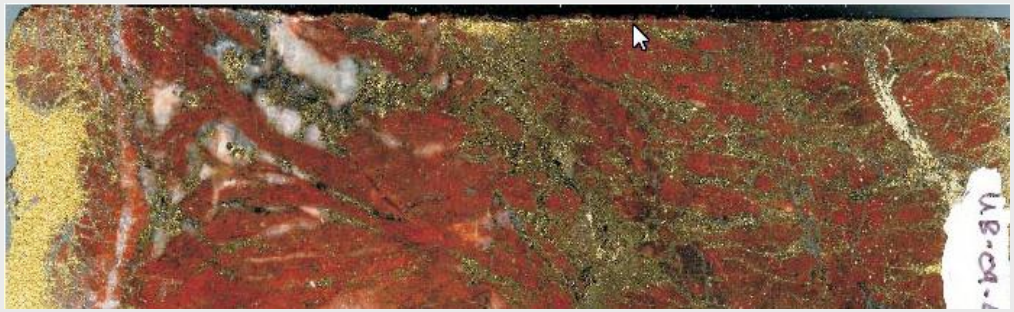


Main Ore Zone: Steeply plunging (SE) series of vein/alteration packages at syenite-volcanic contact







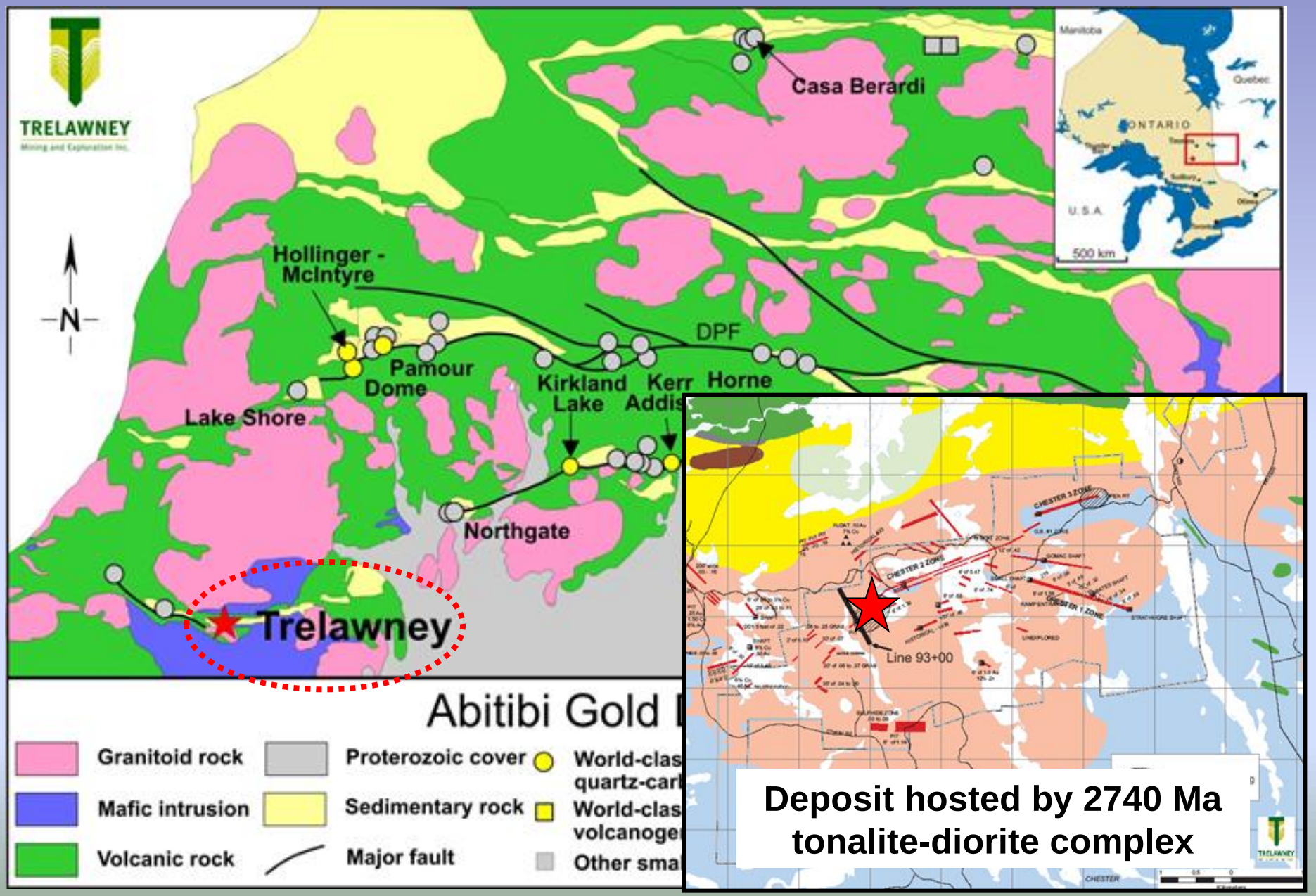


Features of Mineralization:

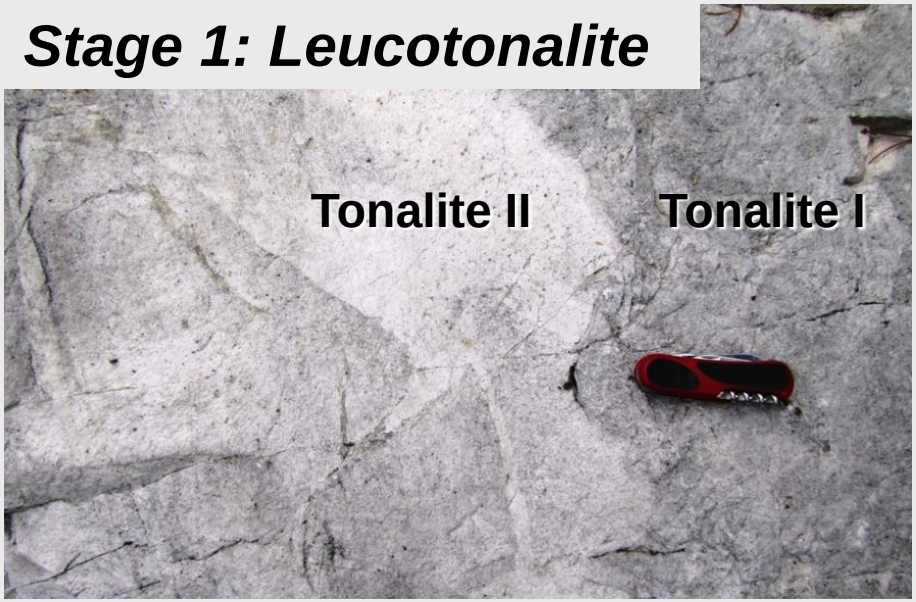
- Dated (Re-Os) at 2685 Ma – thus overlaps syenite.
- Au-Cu-(Ag-Mo-Te-W-Bi-Hg) association (alkaline magmatism).
- **Overlap of magmatic and hydrothermal breccias.**
- Extensive alteration – epidote, actinolite, Mt-Hmt, sericite, tourmaline; **Au correlated with sericite alteration**

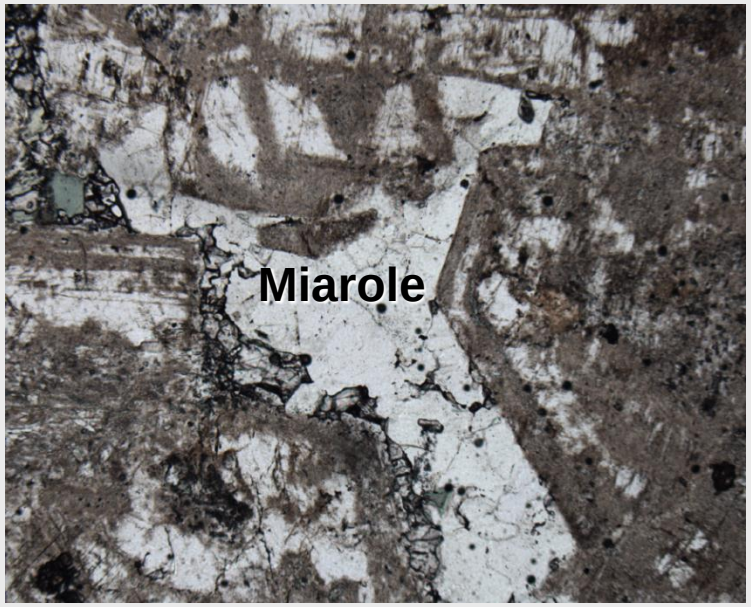
This is a oxidized, magmatic, syenite-associated Au-(Cu) deposit.

Côté Lake Au-Cu Deposit



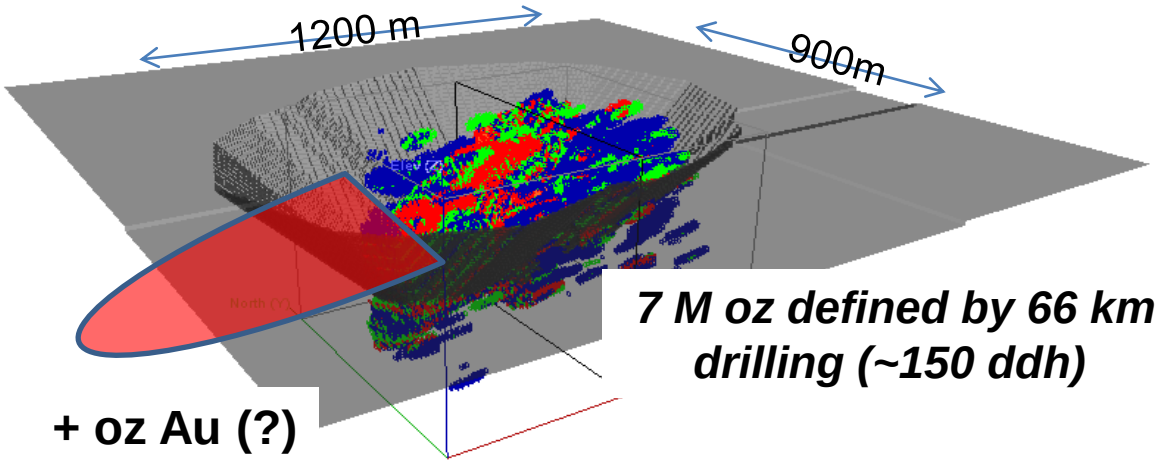
Stage 1: Leucotonalite





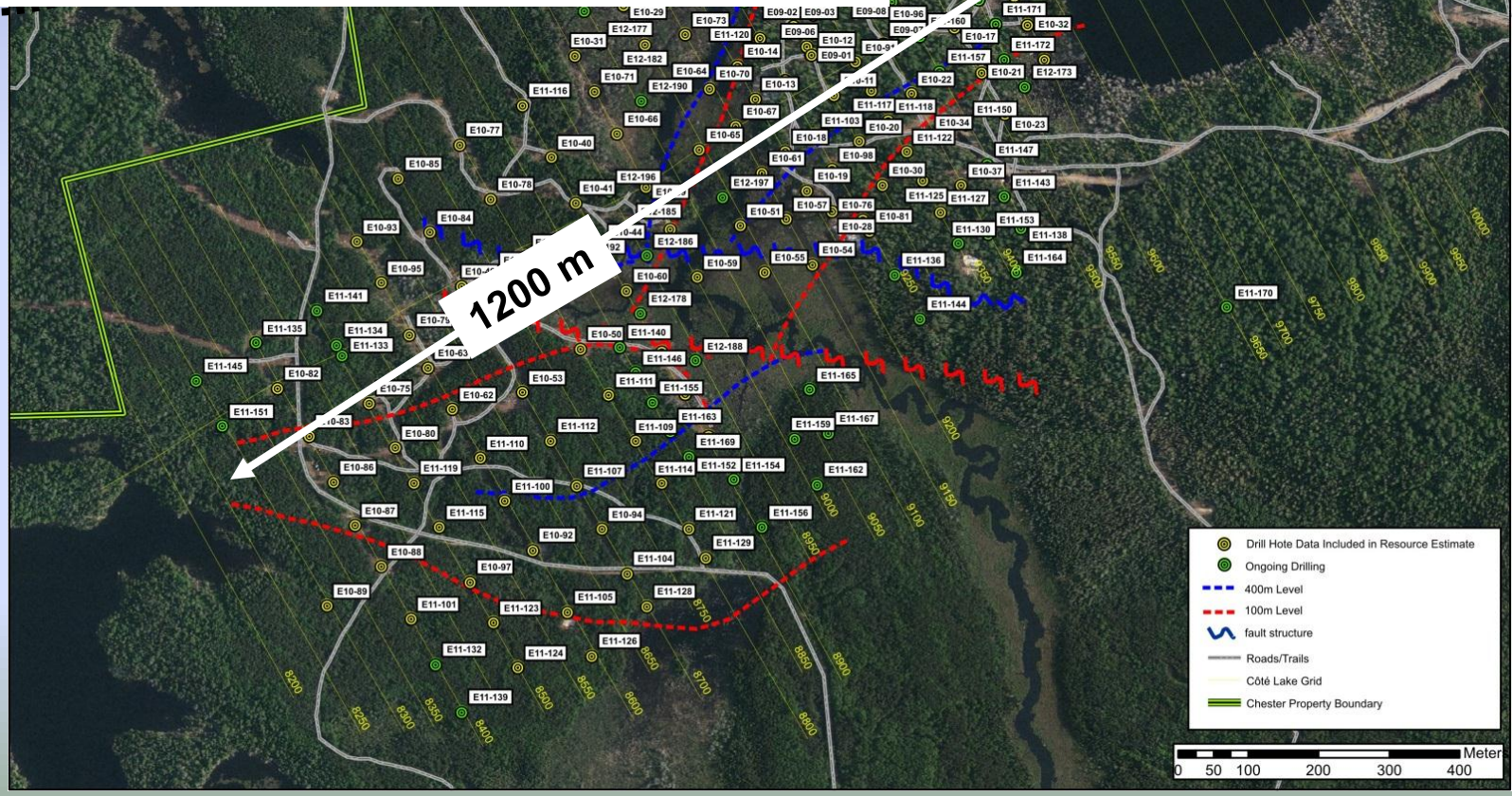
Stage 2: Diorite → Evolves to hydrothermal system

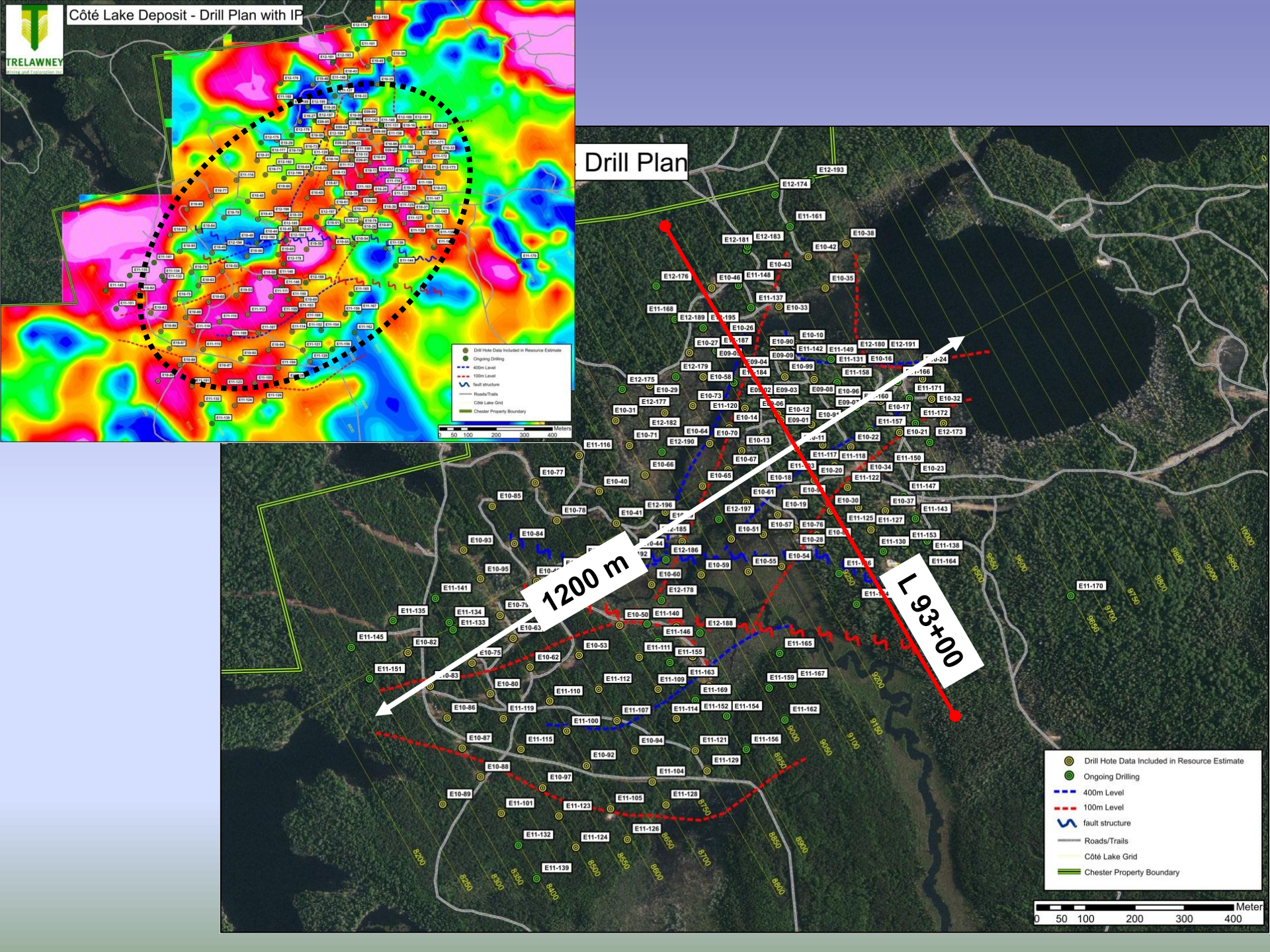
Mineralization (1-2 g/t Au-Cu) in a 2740 Ma magmatic – hydrothermal breccia body with disseminated and stockwork pyrite (± cpy)



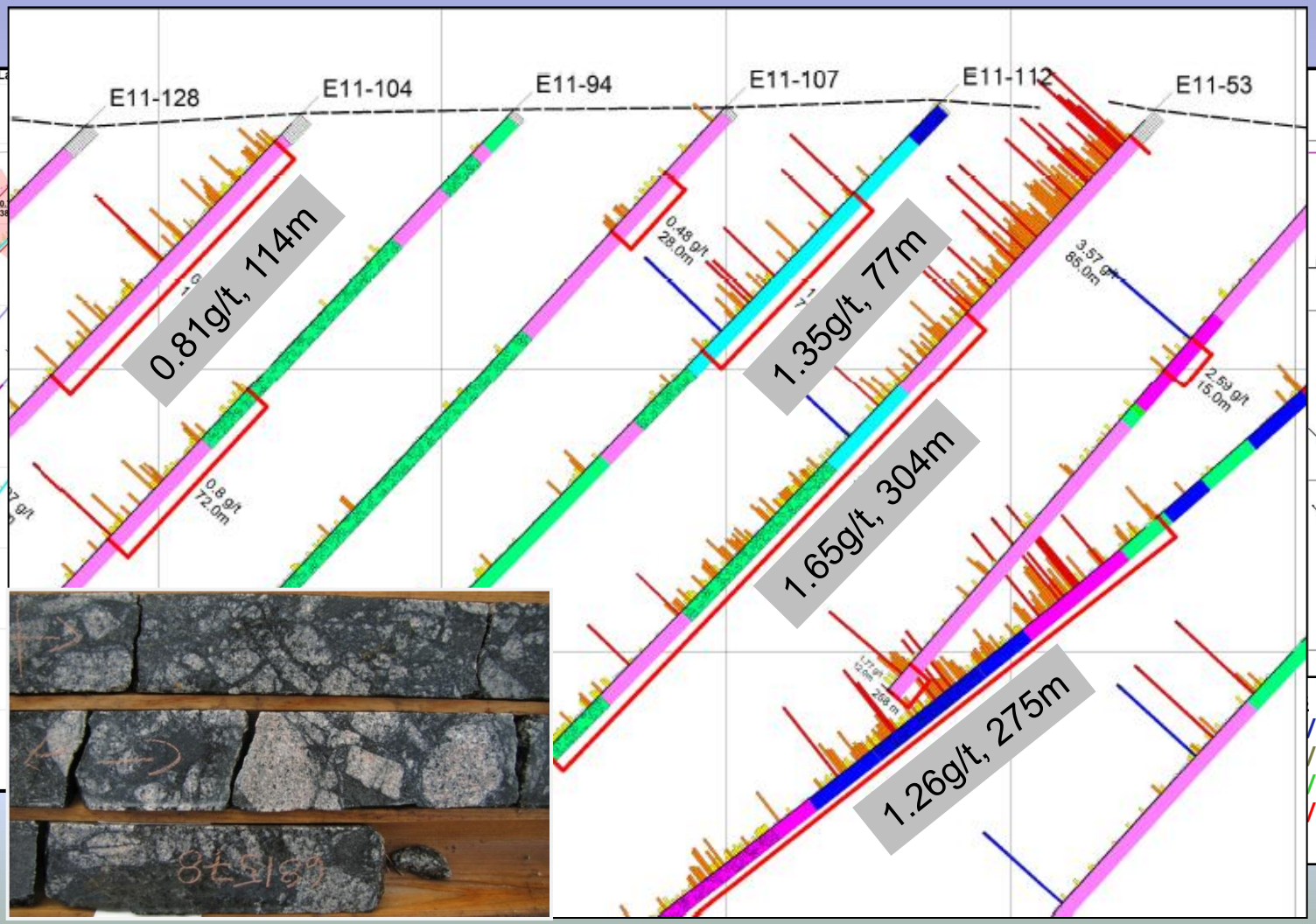
7 M oz defined by 66 km drilling (~150 ddh)

+ oz Au (?)

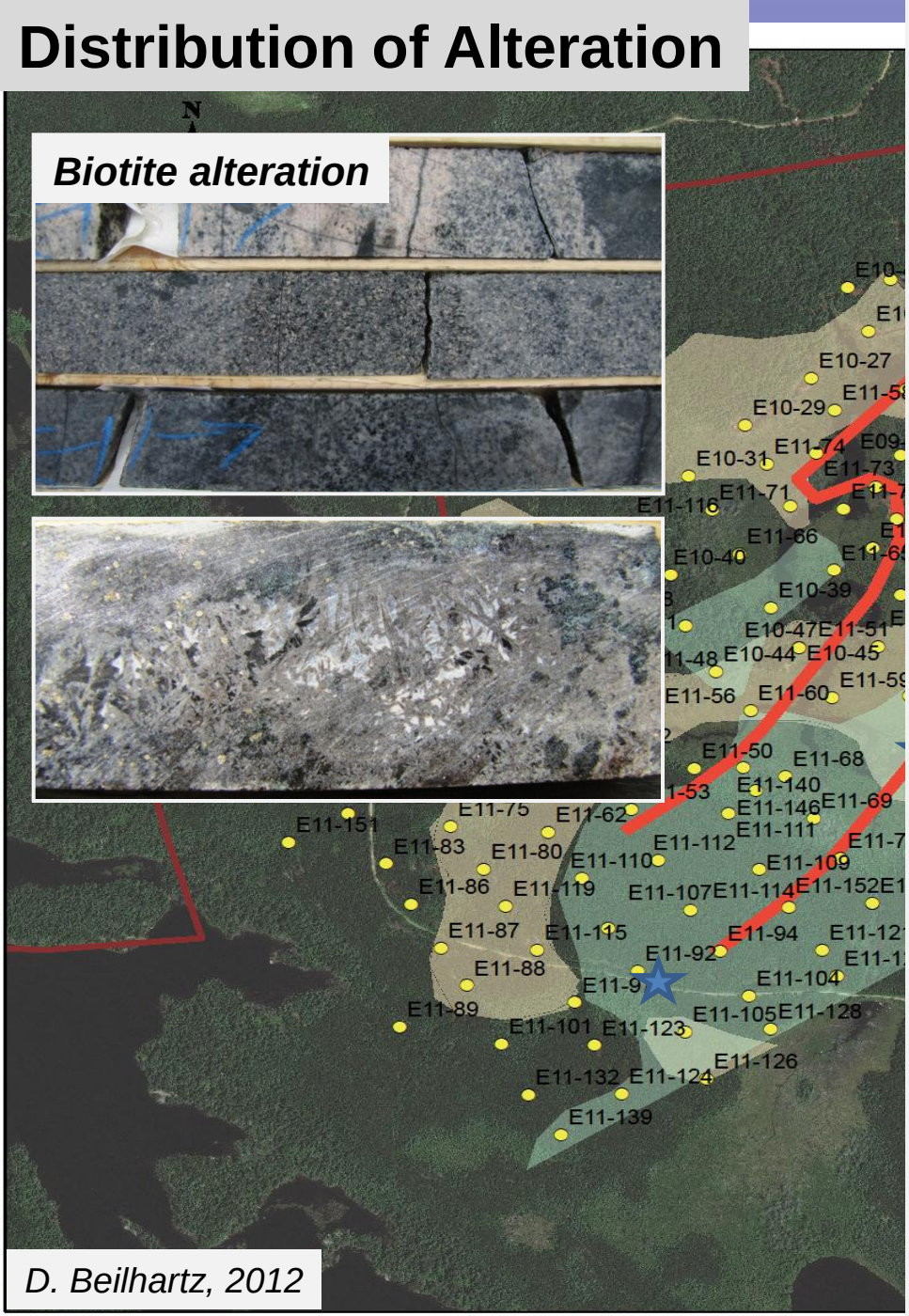



Côté Lake Deposit - Drill Plan with IP
TRELAWNEY
Drill Plan
1200 m
L 93+00
Drill Hote Data Included in Resource Estimate
Ongoing Drilling
400m Level
100m Level
fault structure
Roads/Trails
Côté Lake Grid
Chester Property Boundary
Meters
0 50 100 200 300 400

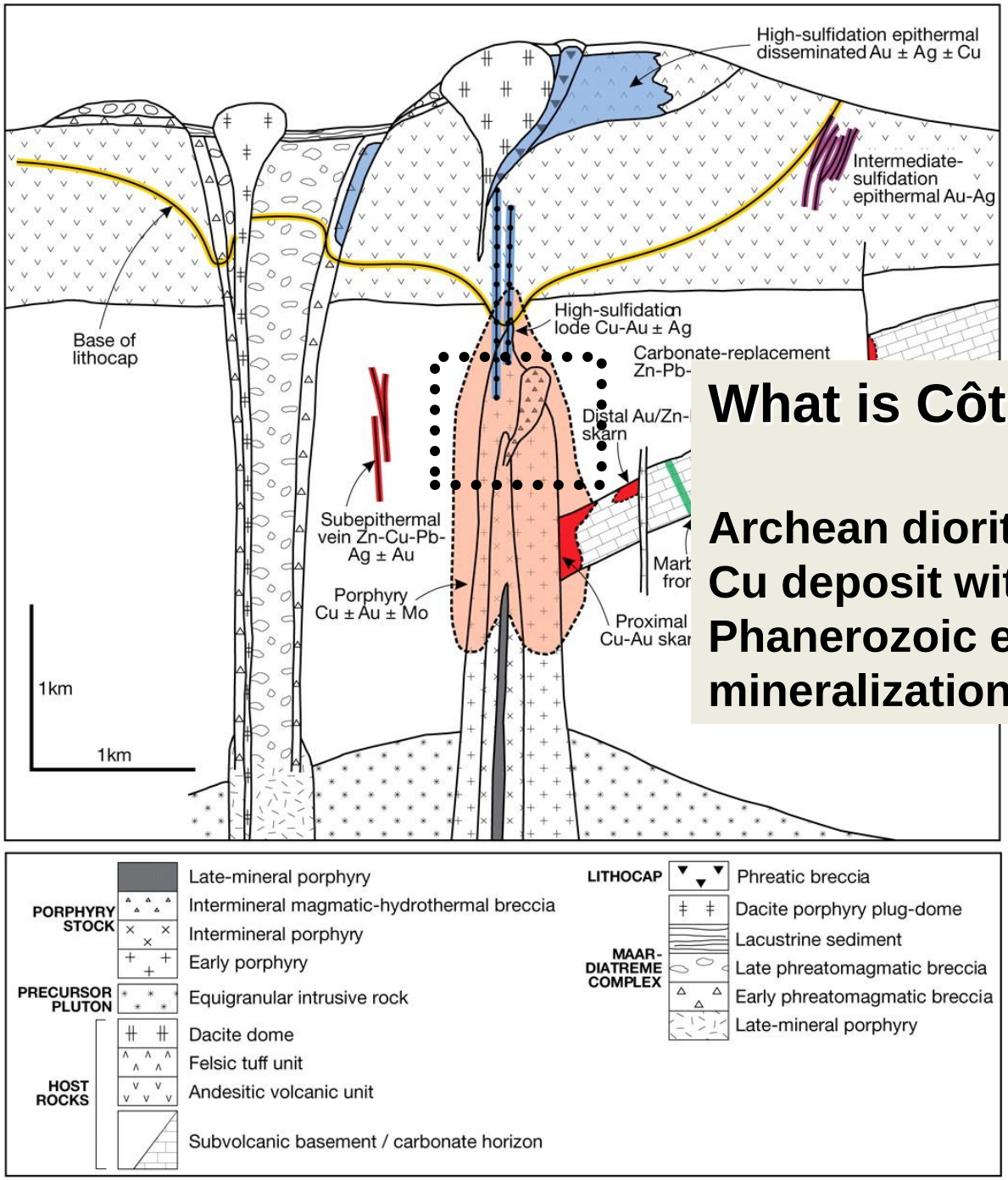
Cote Lake - Section 93+00
(Facing NE)



Distribution of Alteration



D. Beilhartz, 2012



What is Côté Lake:

Archean diorite-tonalite porphyry Au-Cu deposit with analogies to Phanerozoic equivalents – alteration, mineralization (e.g., Sillitoe, 2010)

Summary:

Syenite Deposits:

- Au mineralization spatially and temporally related to 2780 Ma syenitic intrusions.
- Nature of mineralization (vein vs. disseminated), Au grade, (1-30 g/t) and alteration are all variable.
- Mineralizing fluids derived from alkaline magmatic systems.

Tonalite Deposit(s):

- New deposit type for Canadian Archean.
- Porphyry type mineralization and offers potential for other tonalite-diorite settings in Canada and elsewhere.