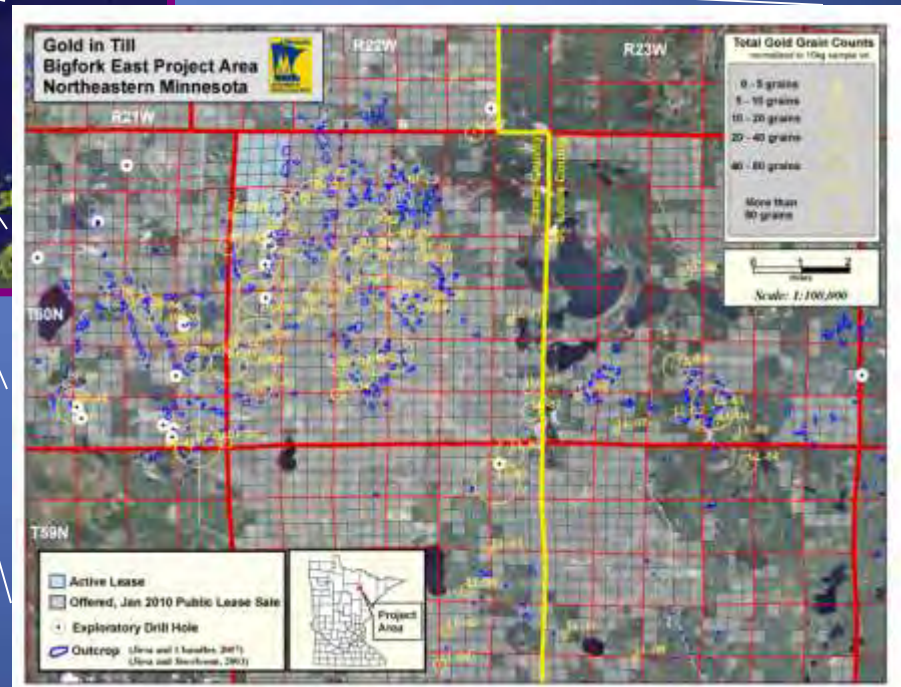
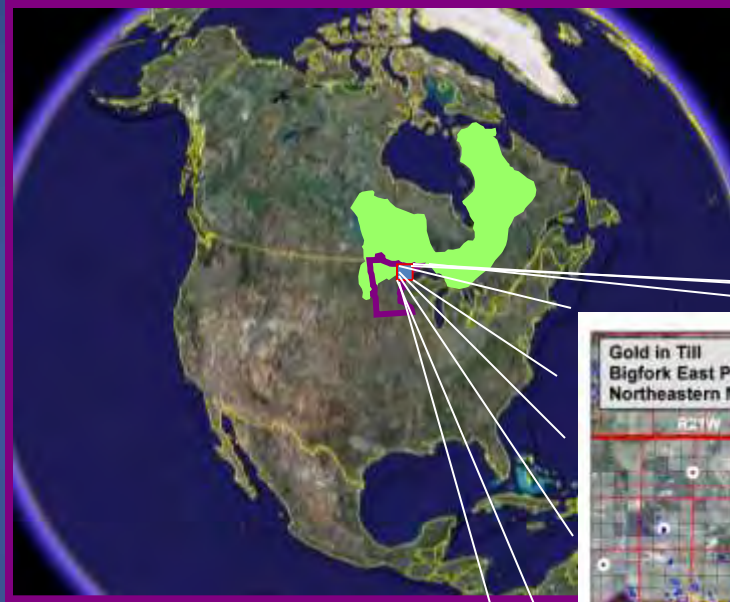


# Regional Survey of Gold in Till, Bigfork East Project Area, Northeastern Minnesota



# Minnesota



The State of Minnesota is located in the northern United States, and shares an international border with Canada.

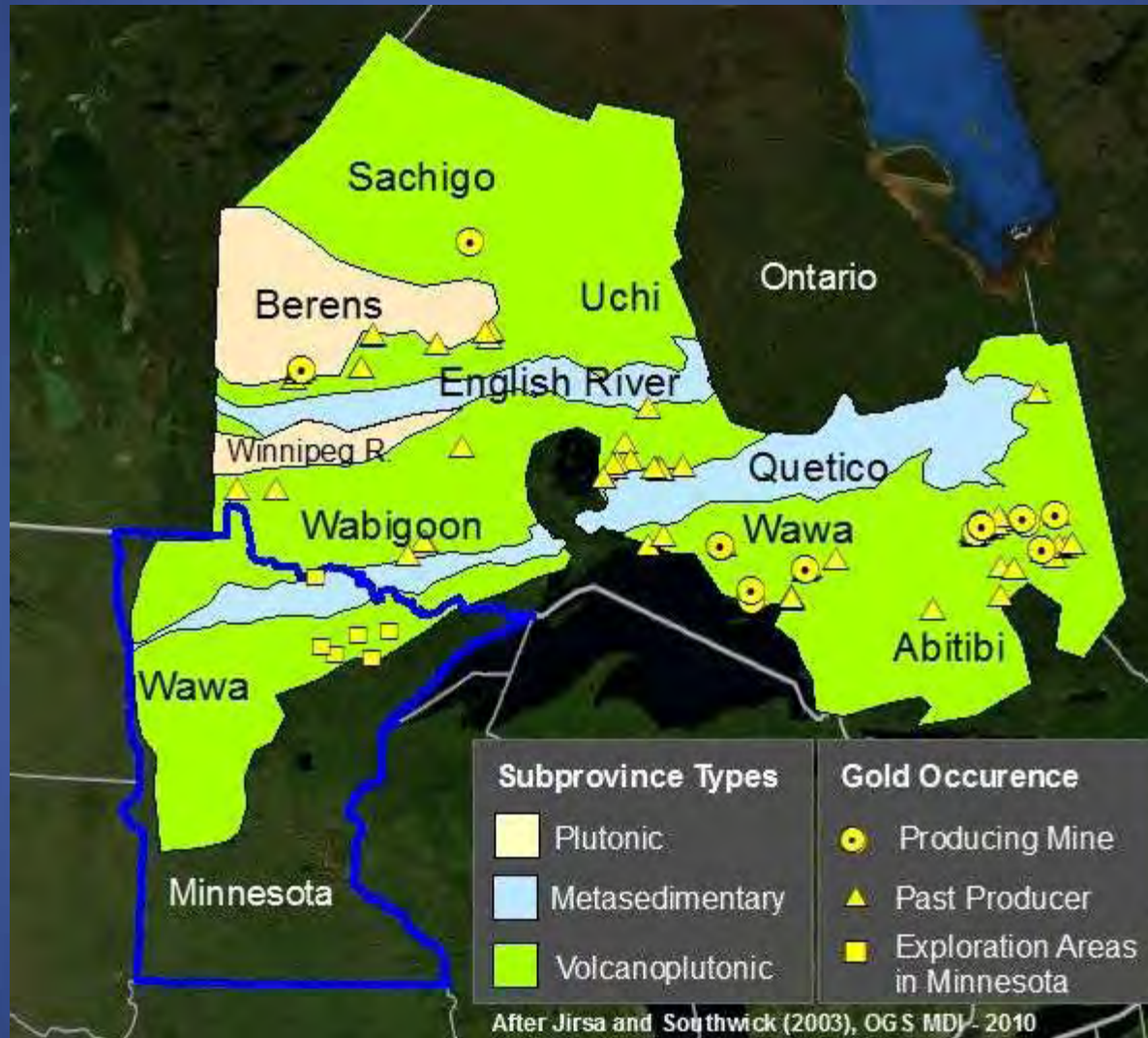
# Archean Superior Province



The northern one-third of the State of Minnesota is part of the ~2.7 Ga Archean Superior Province, which was the continental core for North America. It is also the forms the core of the Canadian Shield.

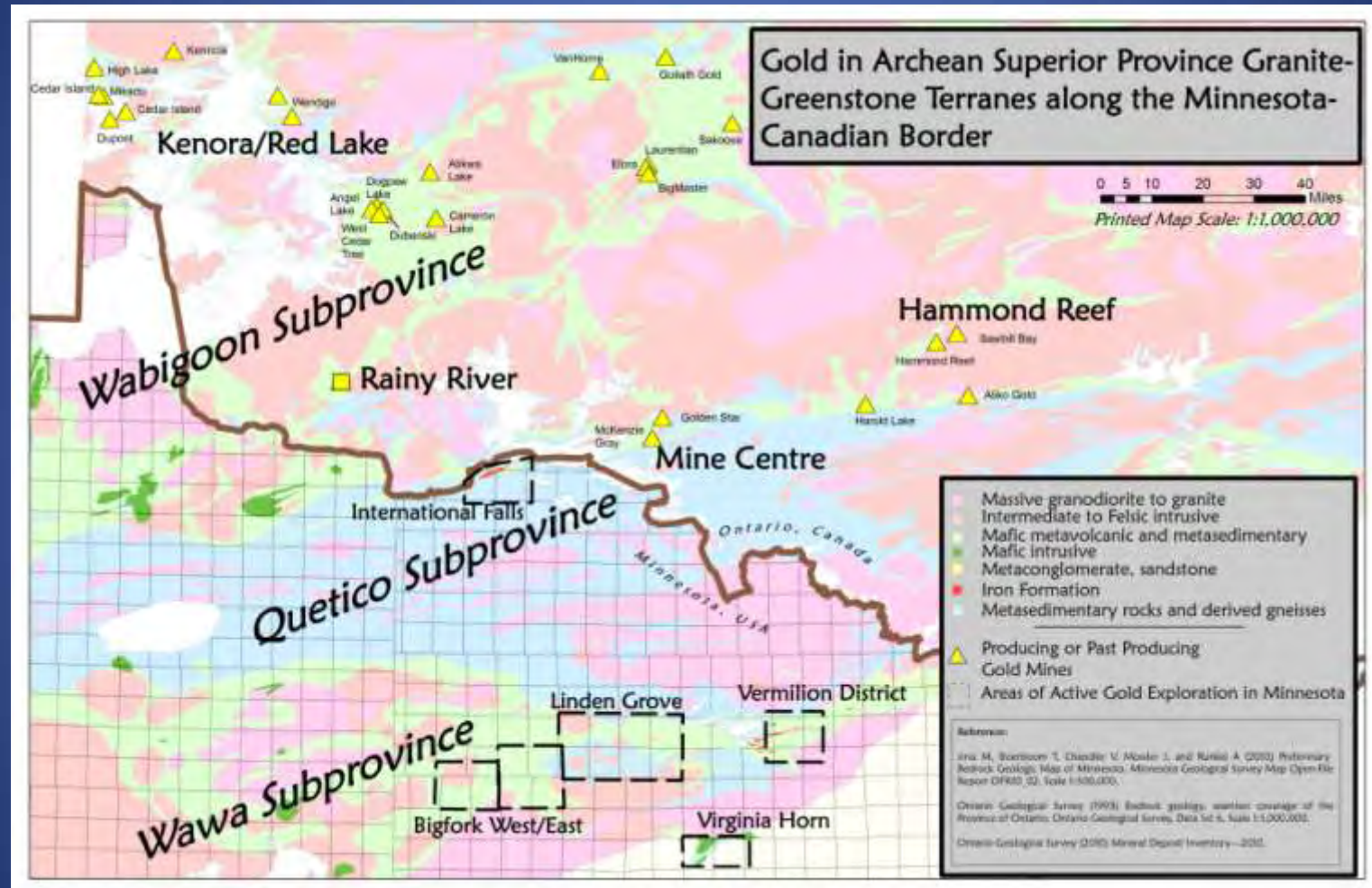


# Archean Superior Province



The Superior Province, broadly speaking, consists of alternating belts of greenstone (green) and plutonic (tan) subprovinces. Two granite-greenstone provinces (Wawa and Wabigoon) are found in Northern Minnesota.

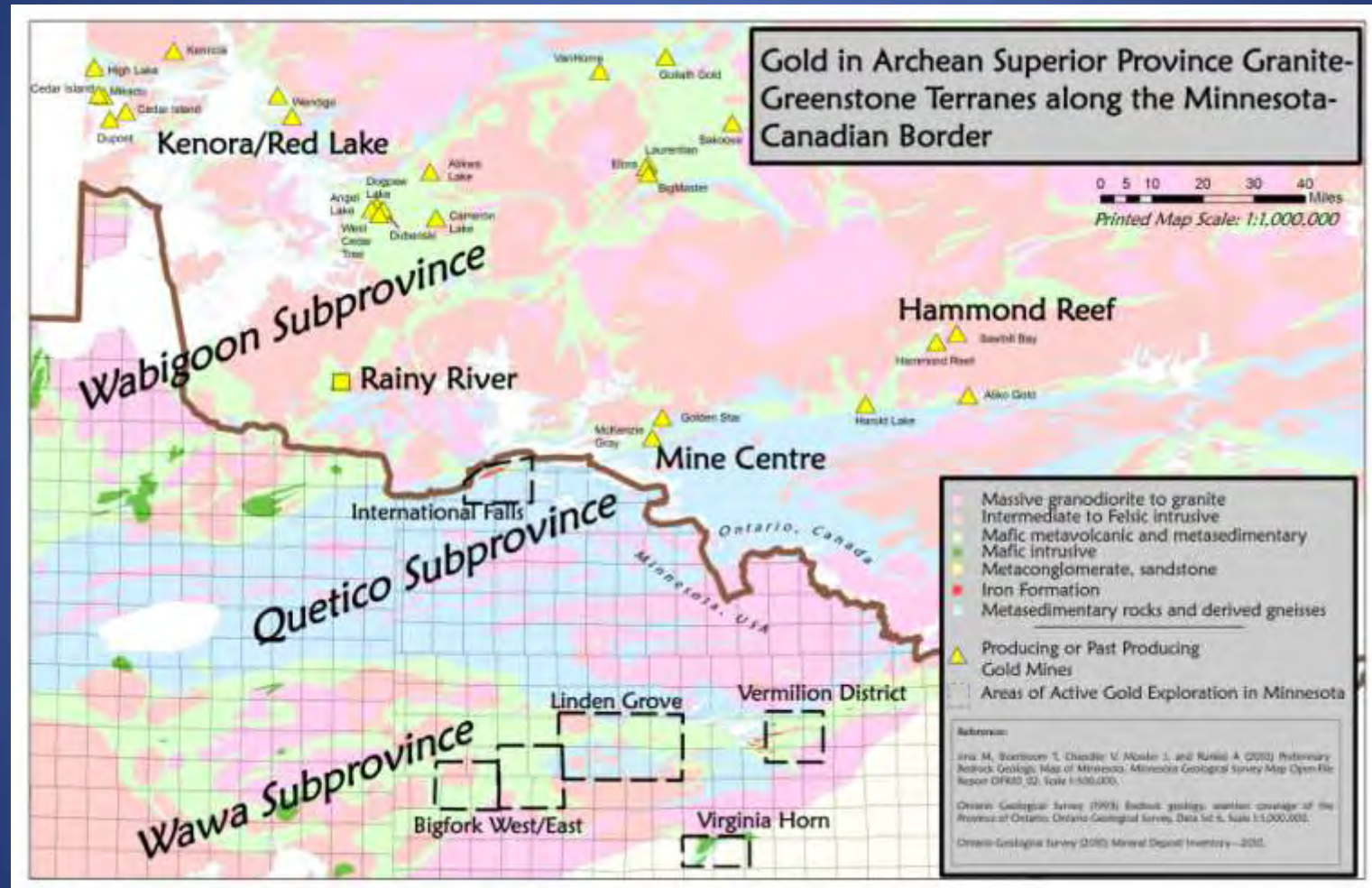
# Mining in the Superior Province



The Superior Province hosts many of the world's richest mineral deposits. The Wabigoon and Wawa Subprovinces, in particular, are mineral rich, and these geologic terranes are found in Minnesota.

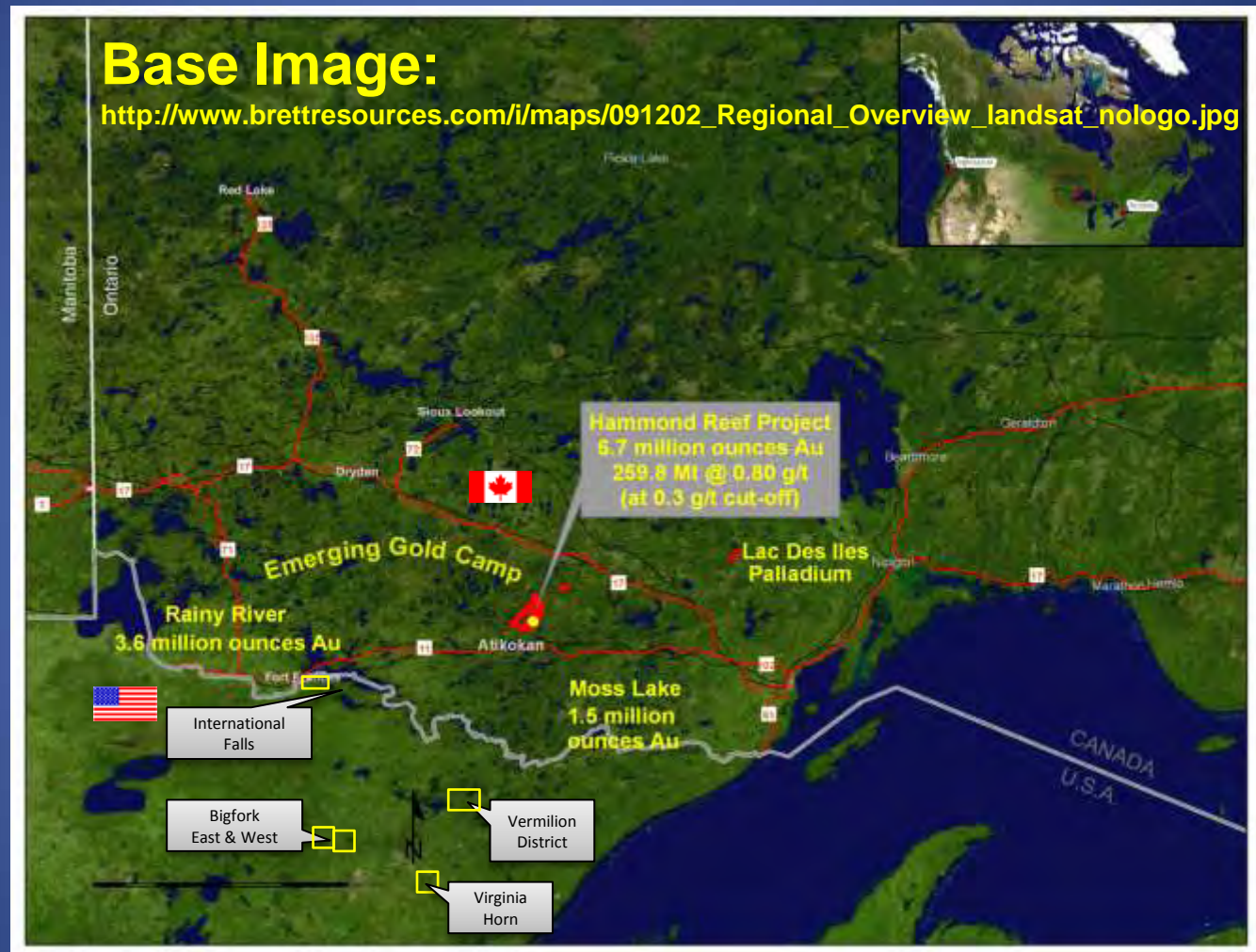


# Geology Along the Border



This simplified geologic map of Northern Minnesota and Northwestern Ontario shows the geologic continuity of granite greenstone belts along the U.S./Canadian border, and the proximity of Minnesota gold prospects and Canadian gold properties.

# Gold Exploration in Minnesota?

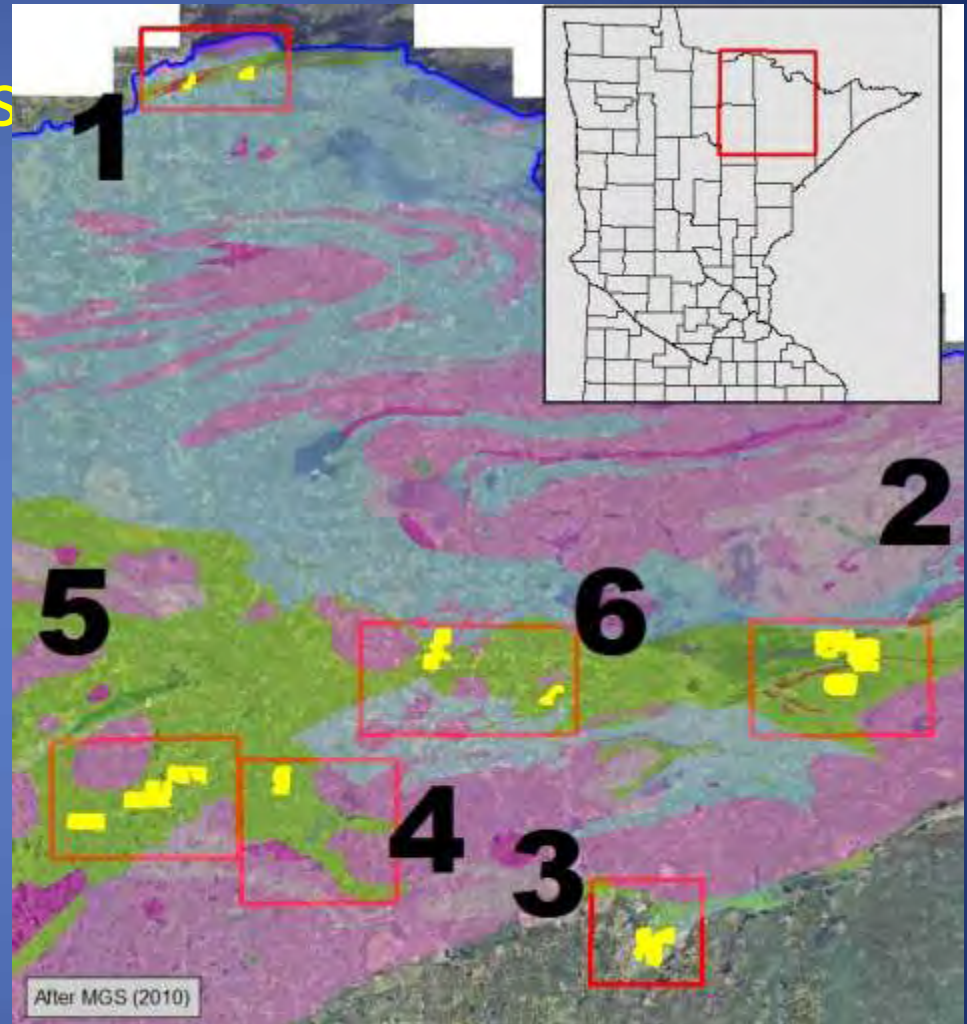


This map was prepared by Brett Resources (see link) to show the proximity of the Hammond Reef gold project and two other major gold resources in Northwestern Ontario, Canada. Gold prospects on the Minnesota side of the U.S./Canadian border are also close to what Brett calls an “Emerging Gold Camp.”



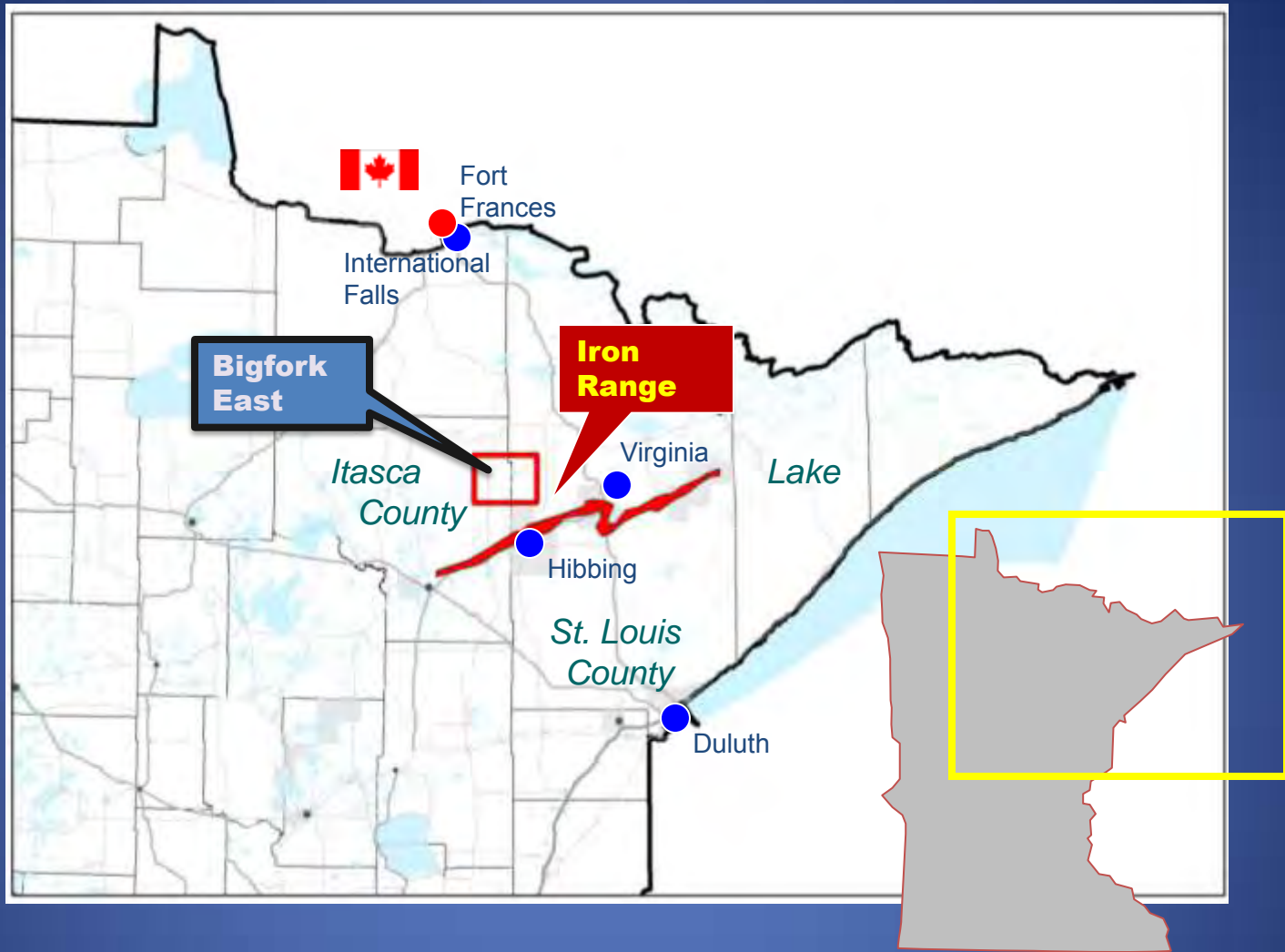
# Gold in Minnesota: Areas of Interest

1. International Falls
2. Vermilion District
3. Virginia Horn
4. Bigfork East
5. Bigfork West
6. Linden Grove



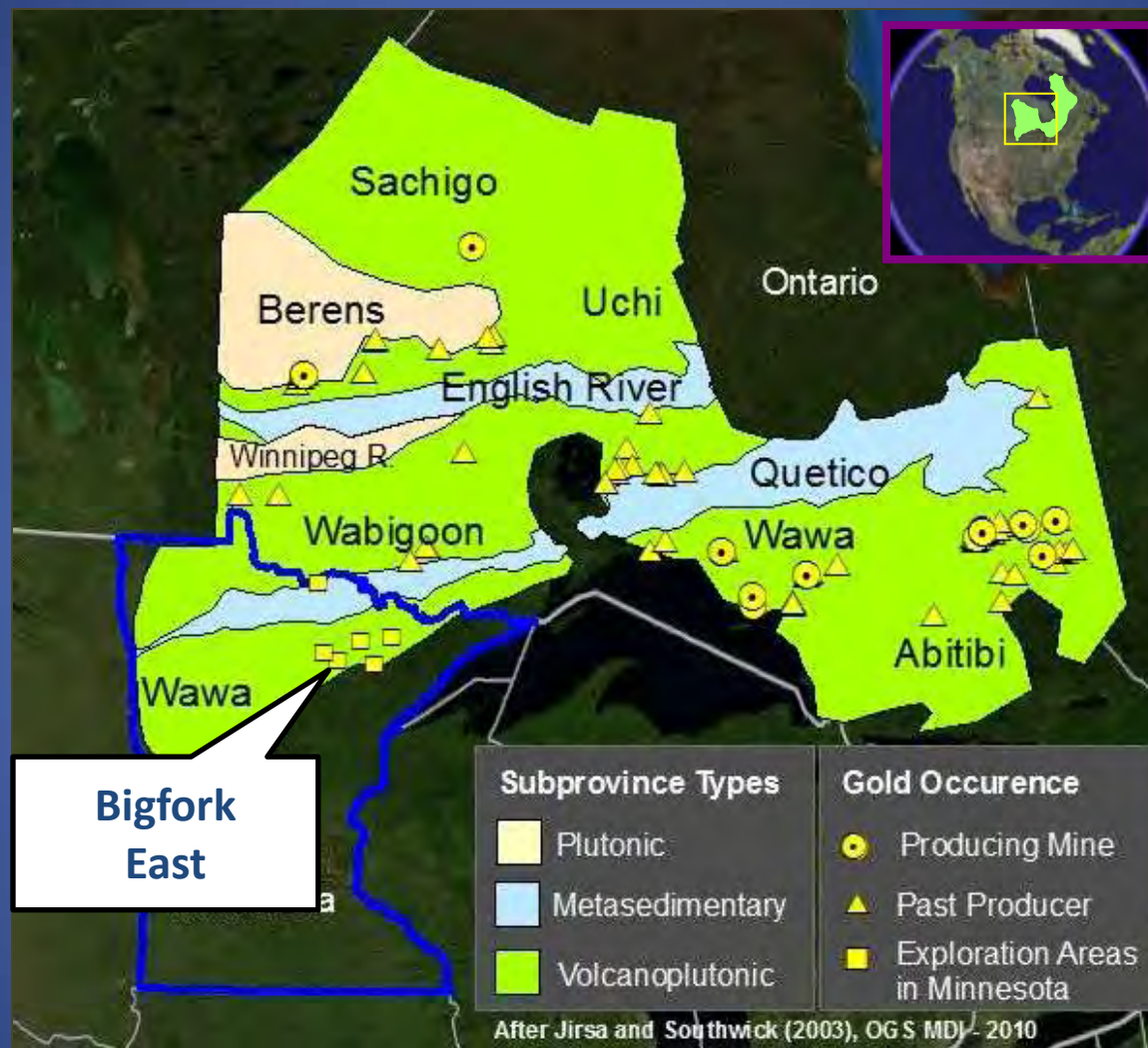
There are currently six separate areas of active gold exploration in Northern Minnesota. The State offers mineral leases, including areas where gold prospects have been identified, either by historical mineral exploration, subsequent geologic mapping, and/or new gold in till sampling programs.





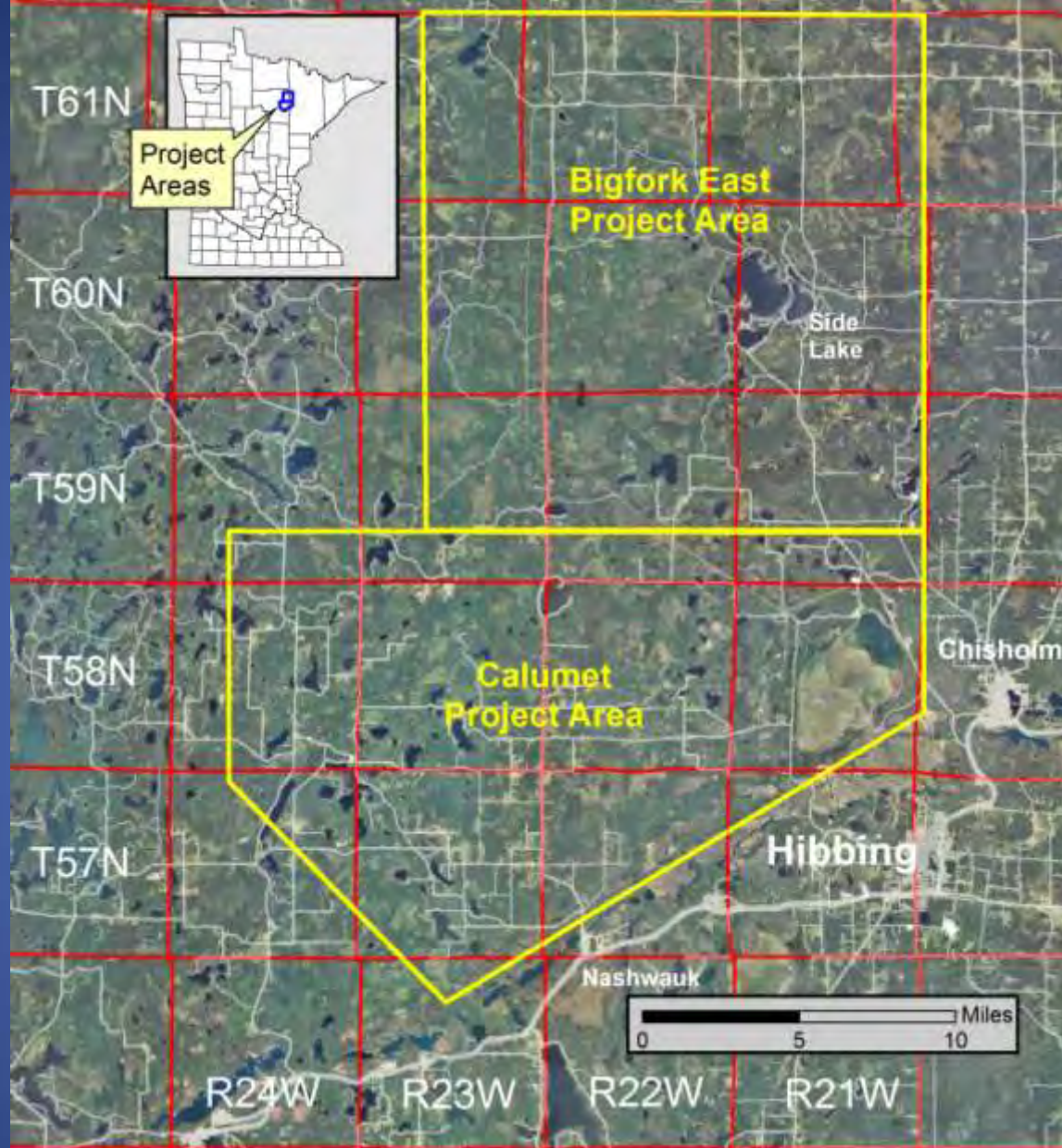
The Bigfork East Project area is located in Northeastern Itasca and Western St. Louis Counties, approximately 50km or 30 miles north of Minnesota's Iron Range and the City of Hibbing.

# Bigfork East

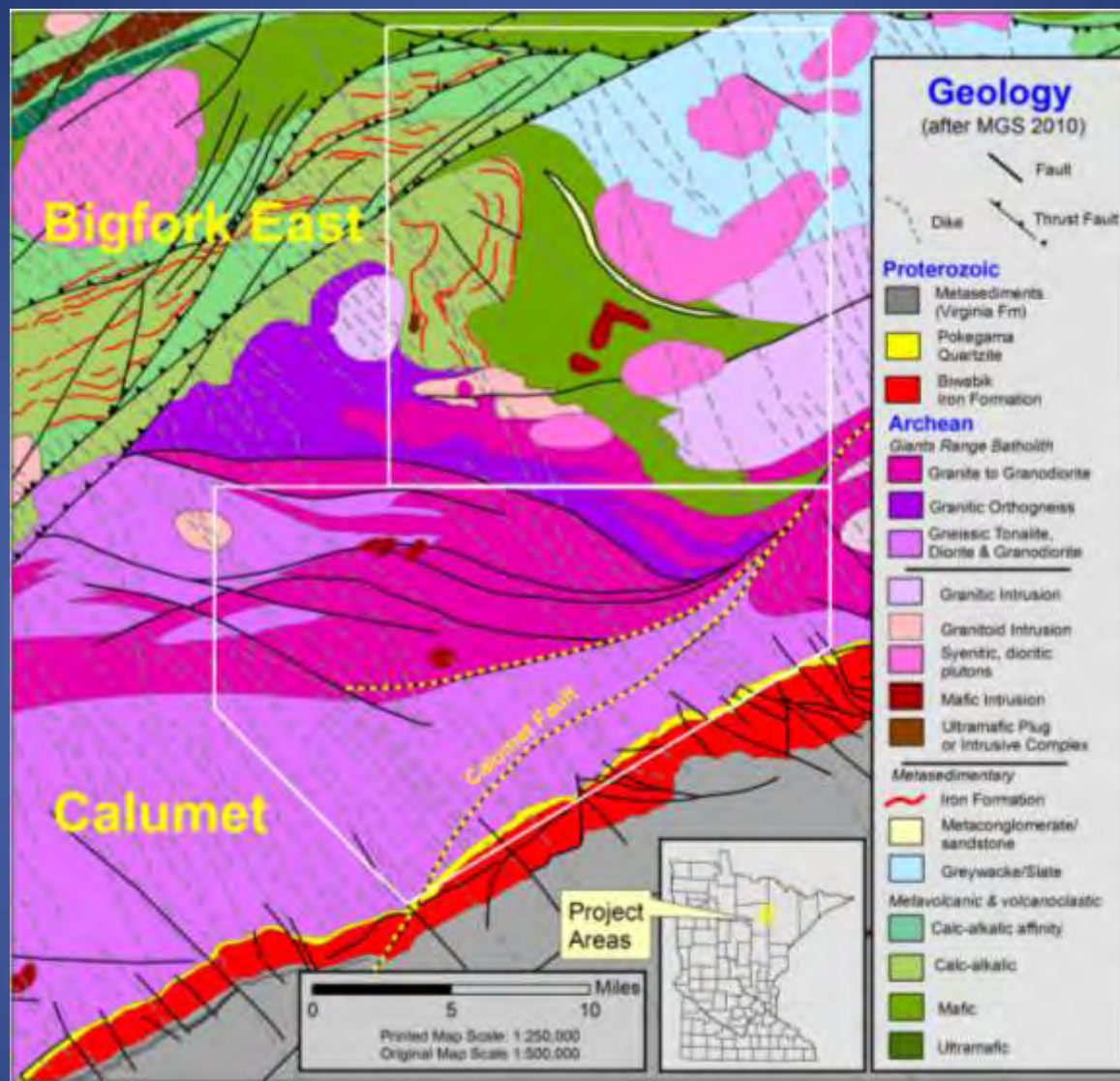


The Bigfork East Project Area is located within the Wawa Subprovince of the Archean Superior Province of North America.



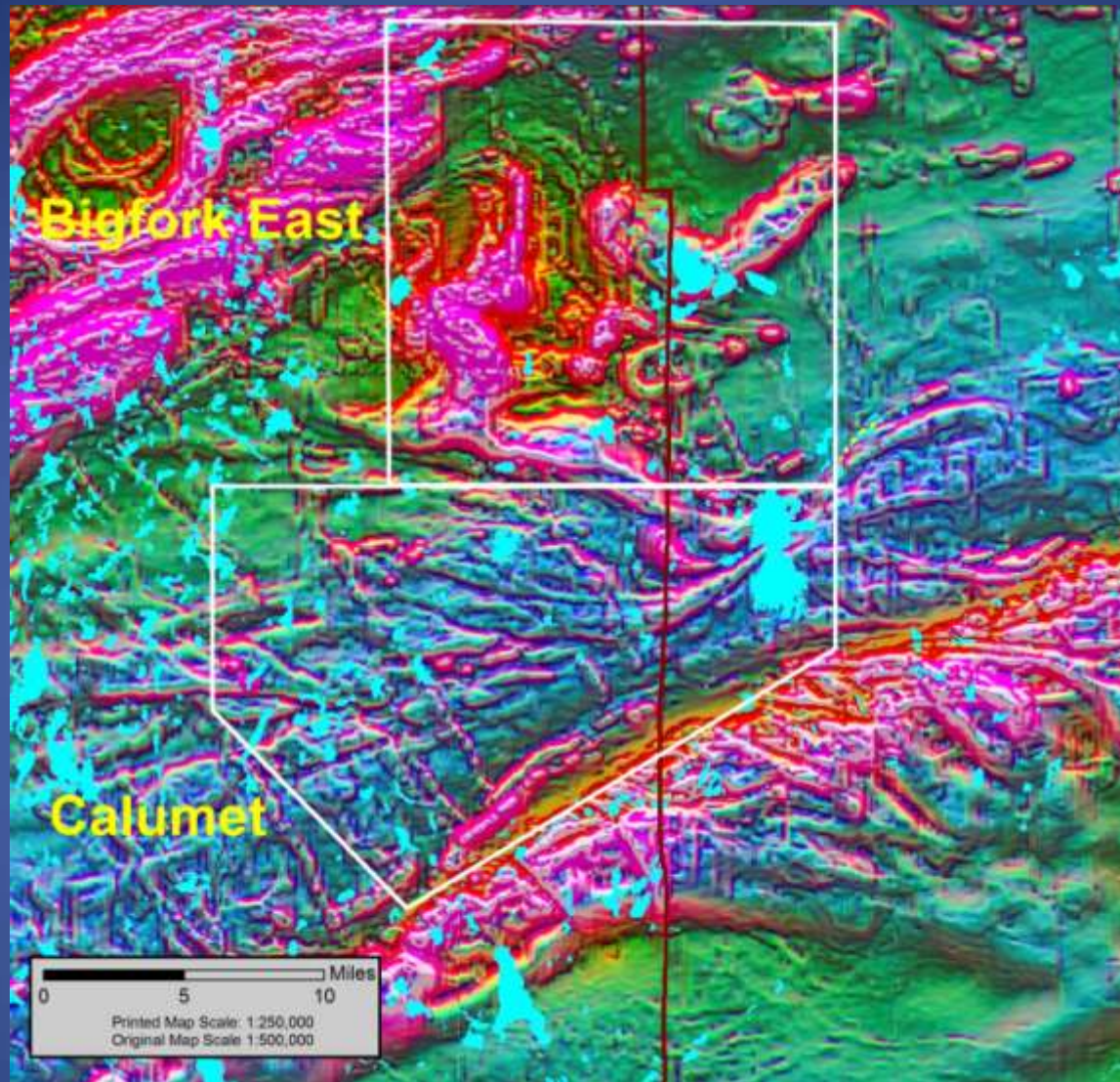


The Bigfork East Project Area is one of two areas of MnDNR investigation in the Archean granite-greenstone terrane north of Hibbing and the Iron Range.



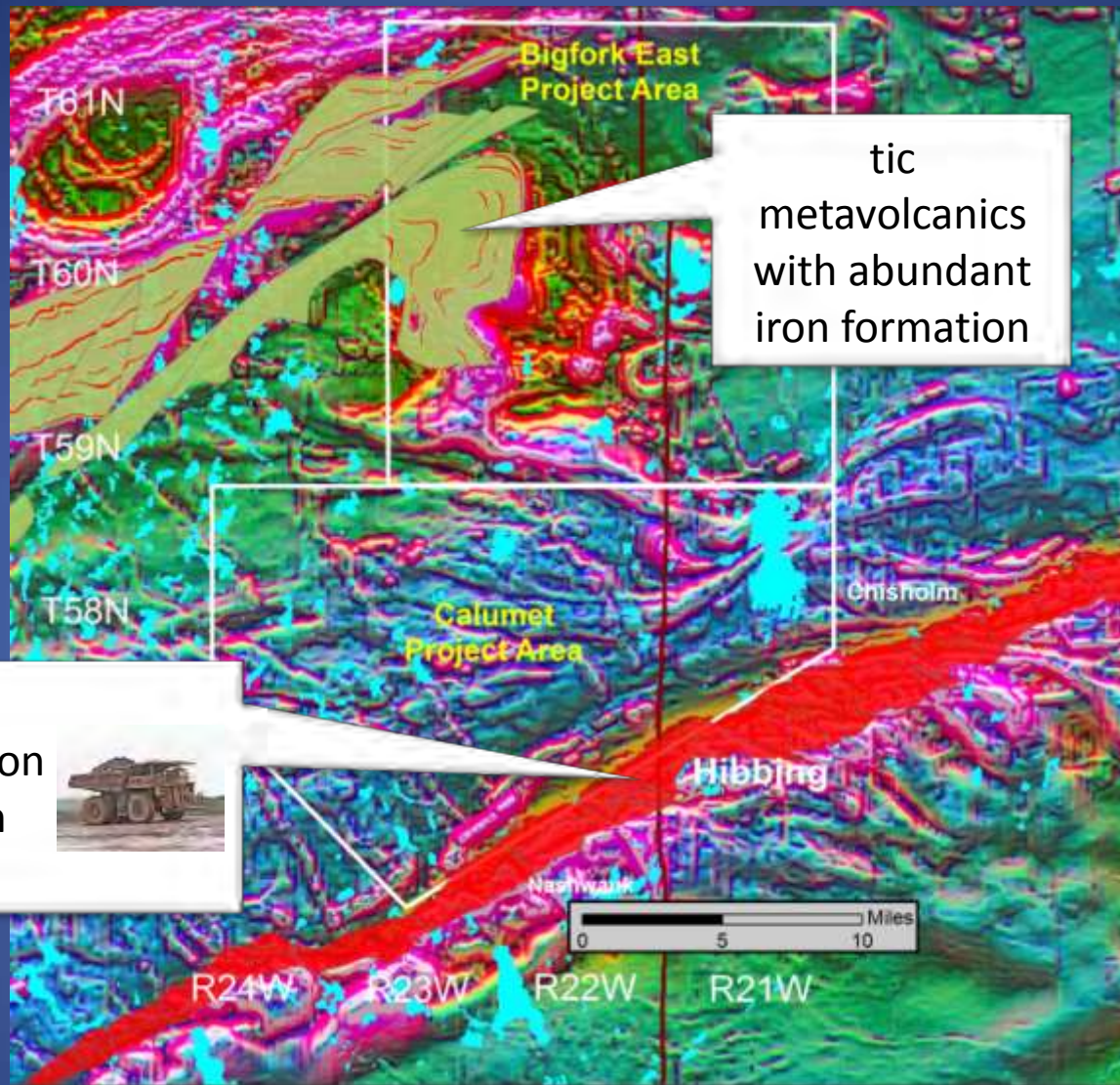
The Bigfork East Project Area is located within the “greenstone” portion of an Archean granite-greenstone terrane north of Hibbing, while the Calumet Project Area covers the “granite” part with the Giants Range Batholith.





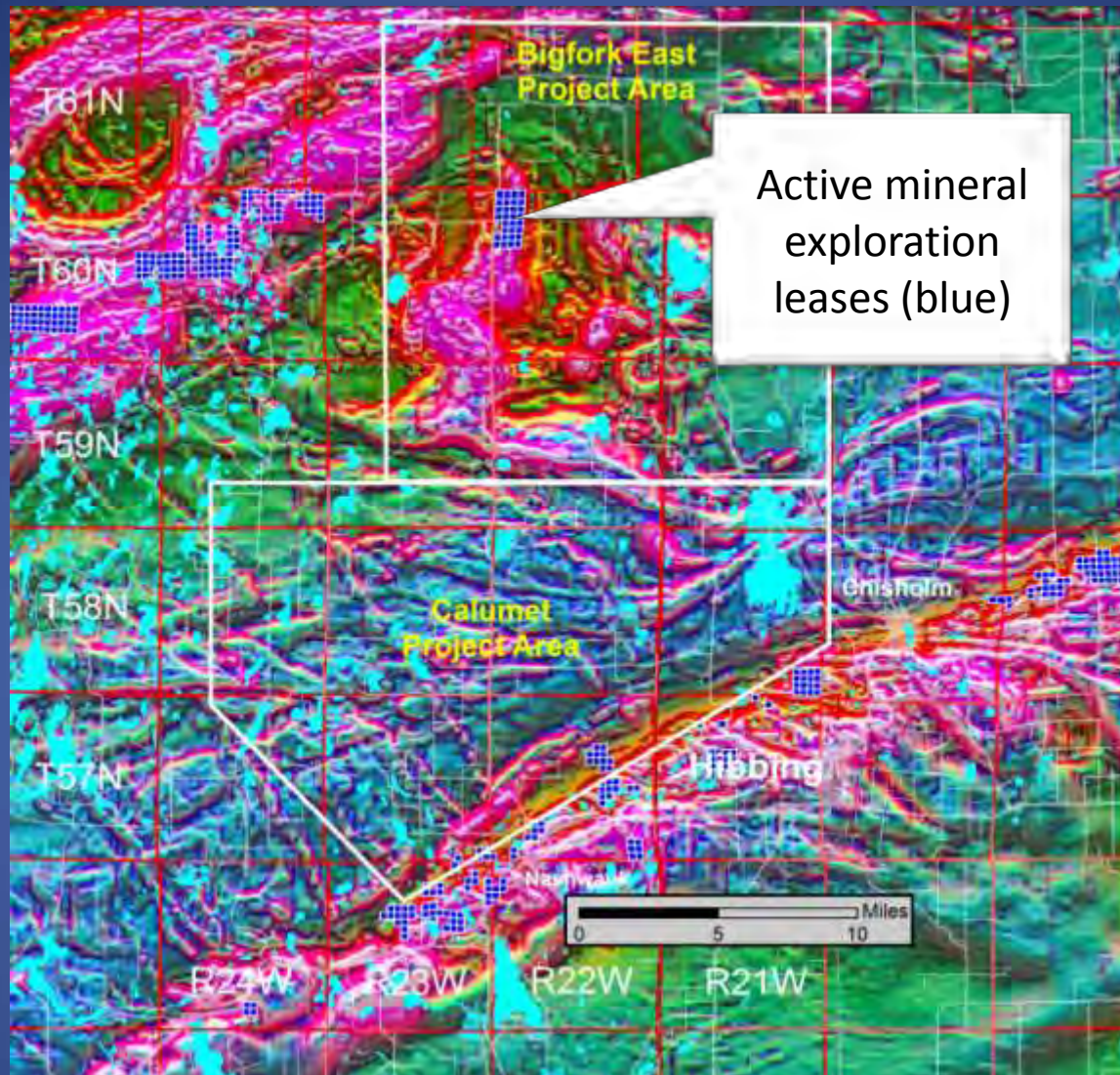
The discontinuous layers of iron formation within the Bigfork East Project Area create strong aeromagnetic highs, similar to those observed over the Biwabik Iron Formation to the South.





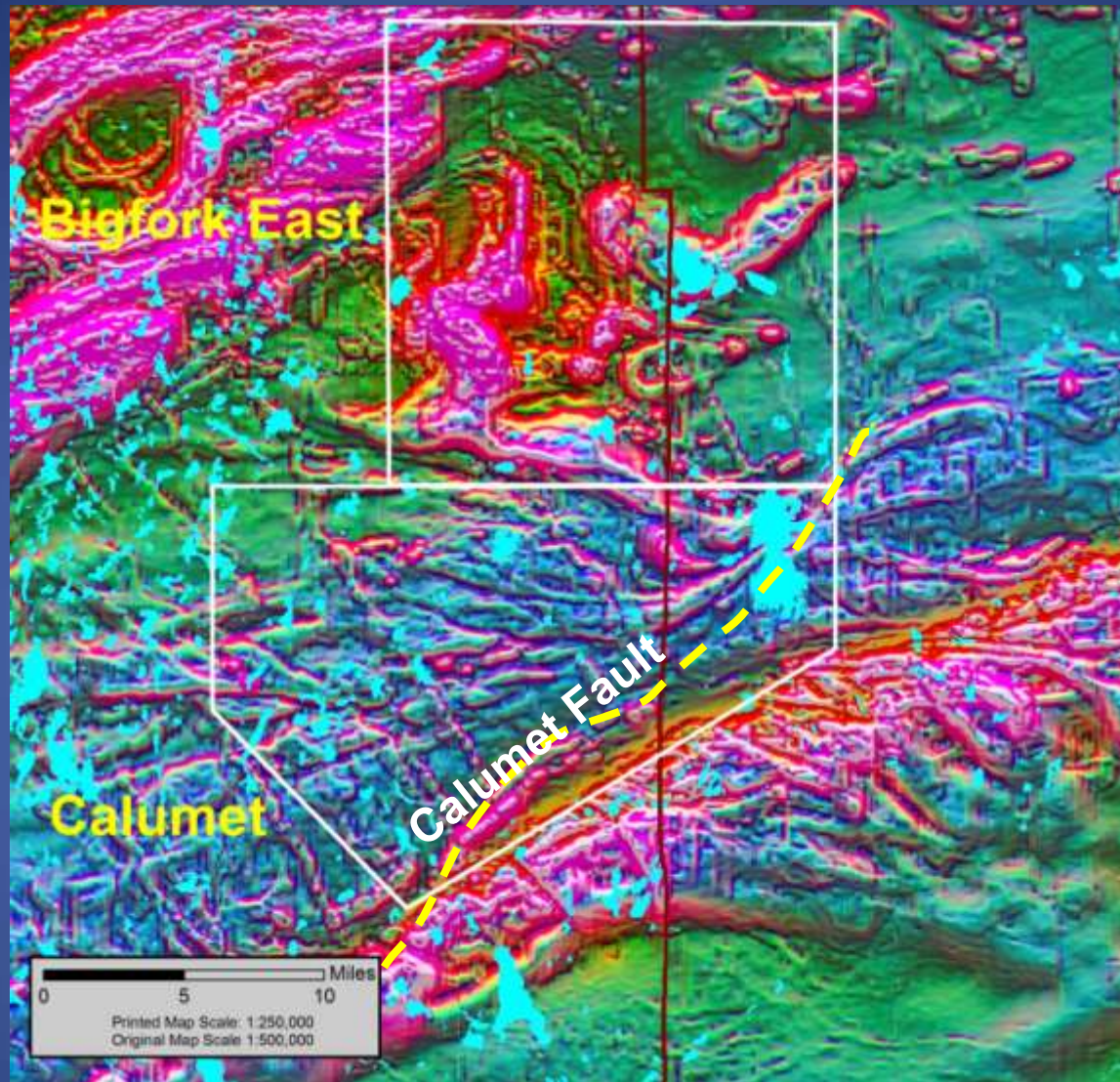
The discontinuous layers of iron formation within the Bigfork East Project Area create strong aeromagnetic highs, similar to those observed over the Biwabik Iron Formation to the South.





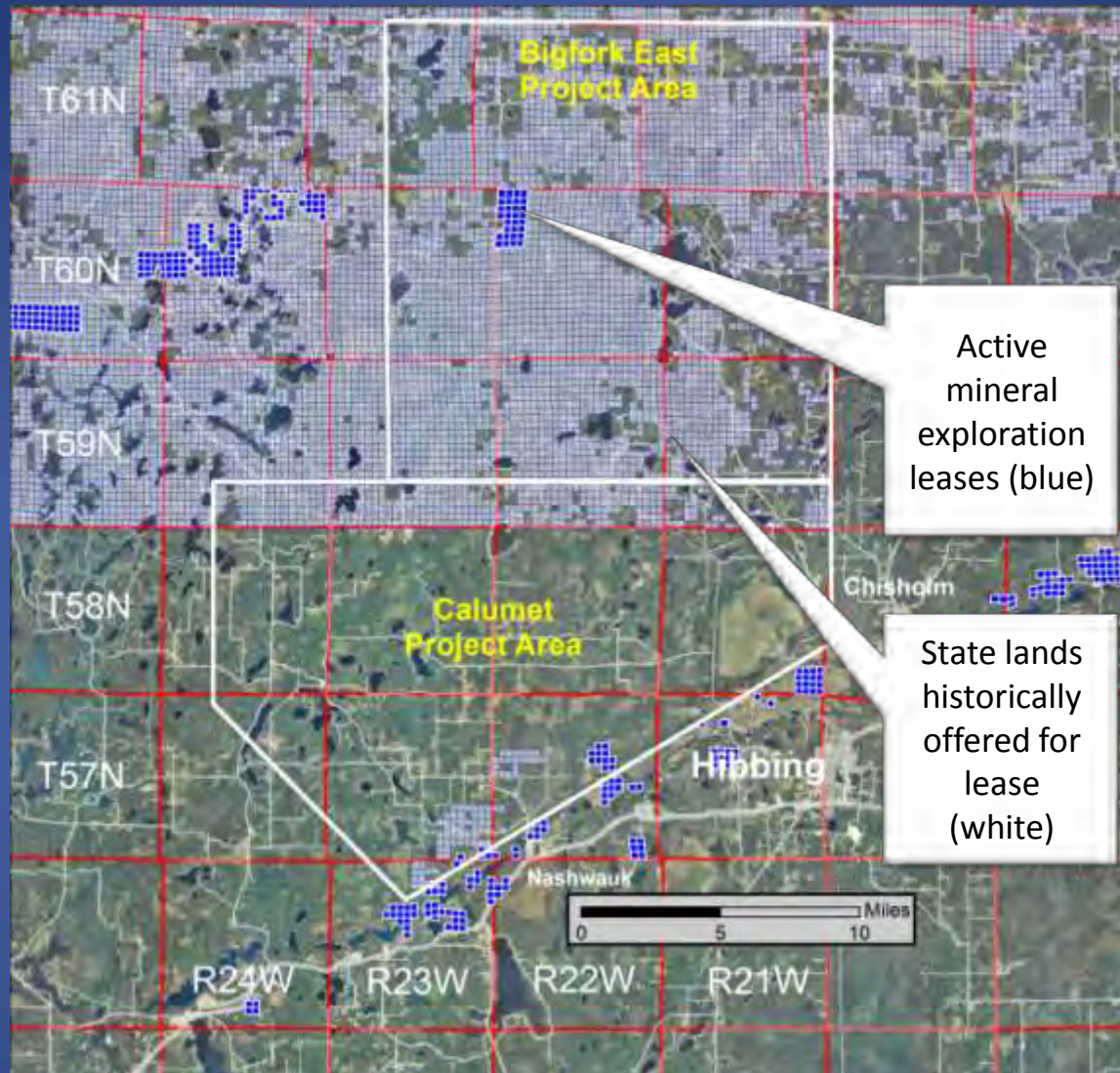
The same metavolcanic/iron formation units are the focus of active mineral exploration under State mineral leases (blue boxes) within and west of the Bigfork East Project Area (blue boxes within the Biwabik Iron Formation are taconite mining leases).



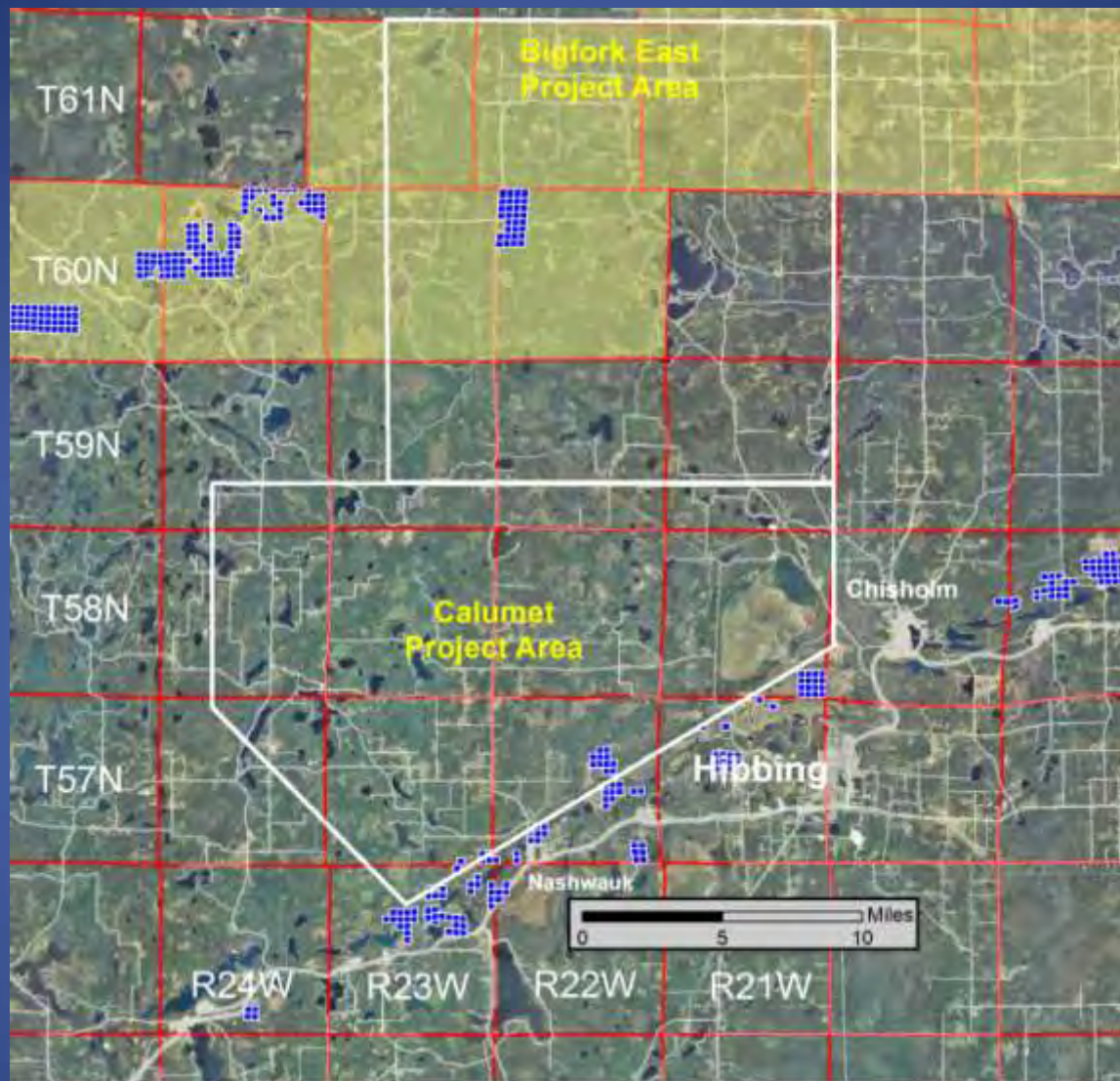


Areas of interest within the Calumet Project area were located where the Giants Range Batholith is cut by major late faults and structural features, such as the Calumet Fault.





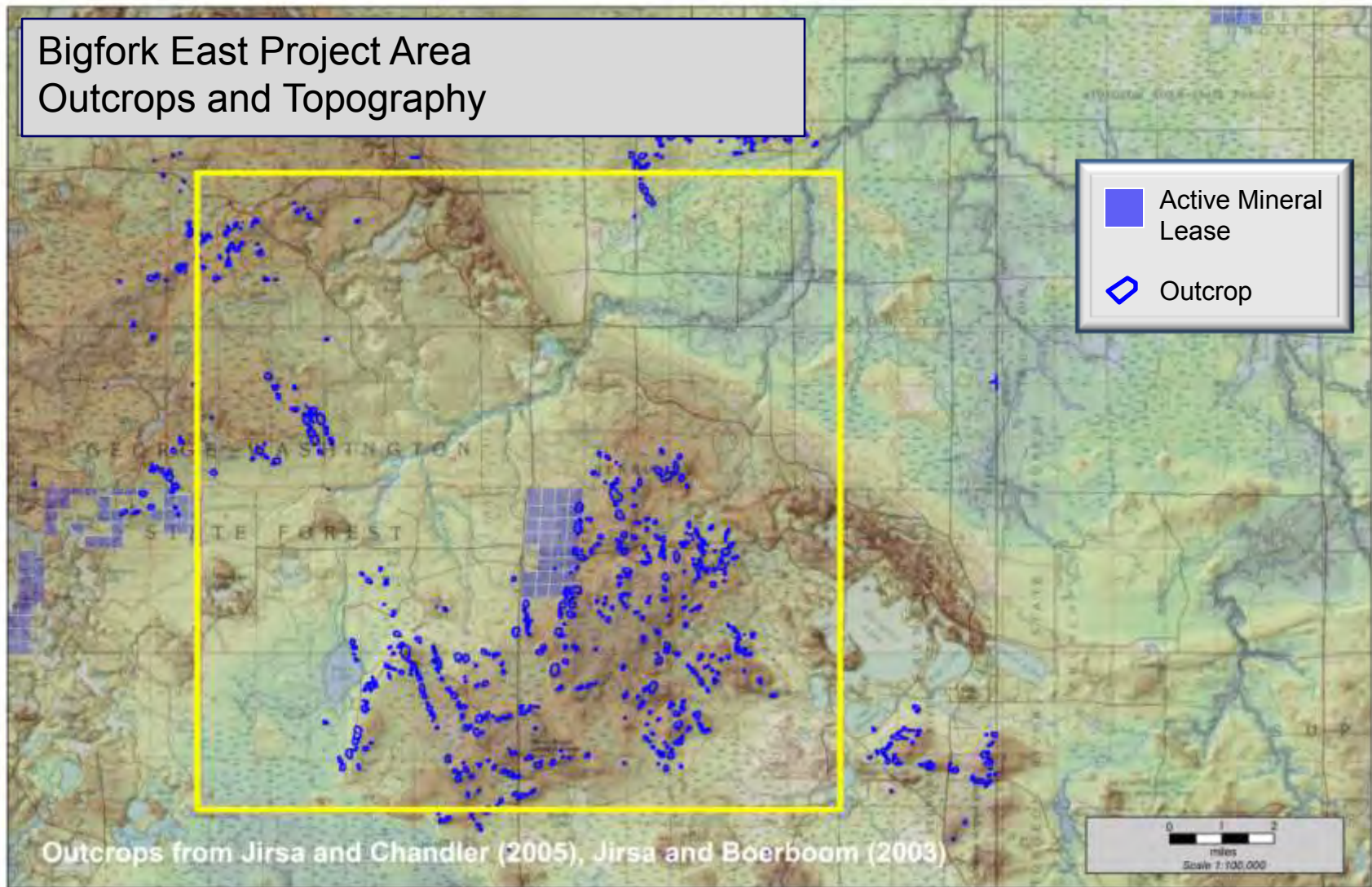
The State of Minnesota holds a dominant land position in the region. Almost all of the greenstone terrane within the Bigfork East Project Area has been offered at some time over the past 40 years under the State Metallic Mineral Lease Program.



This map shows the Areas Under Consideration for the State of Minnesota metallic mineral lease sale on April 28, 2011. The remaining portion of this presentation will focus on the Areas Under Consideration within the Bigfork East Project Area.

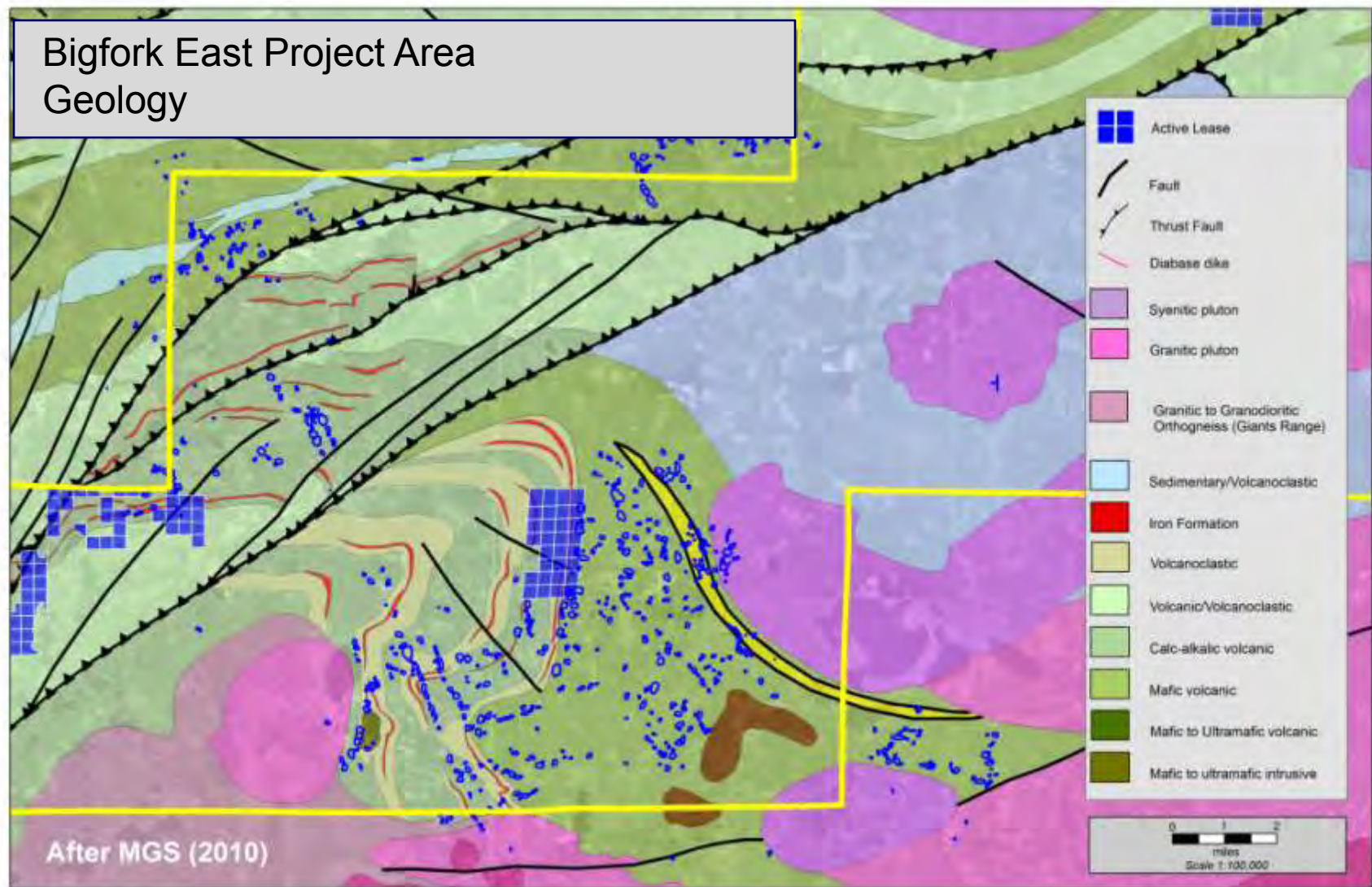


## Bigfork East Project Area Outcrops and Topography



The Bigfork East Project Area is an upland region, with bedrock exposures (blue polygons) generally corresponding to local topographic highs.

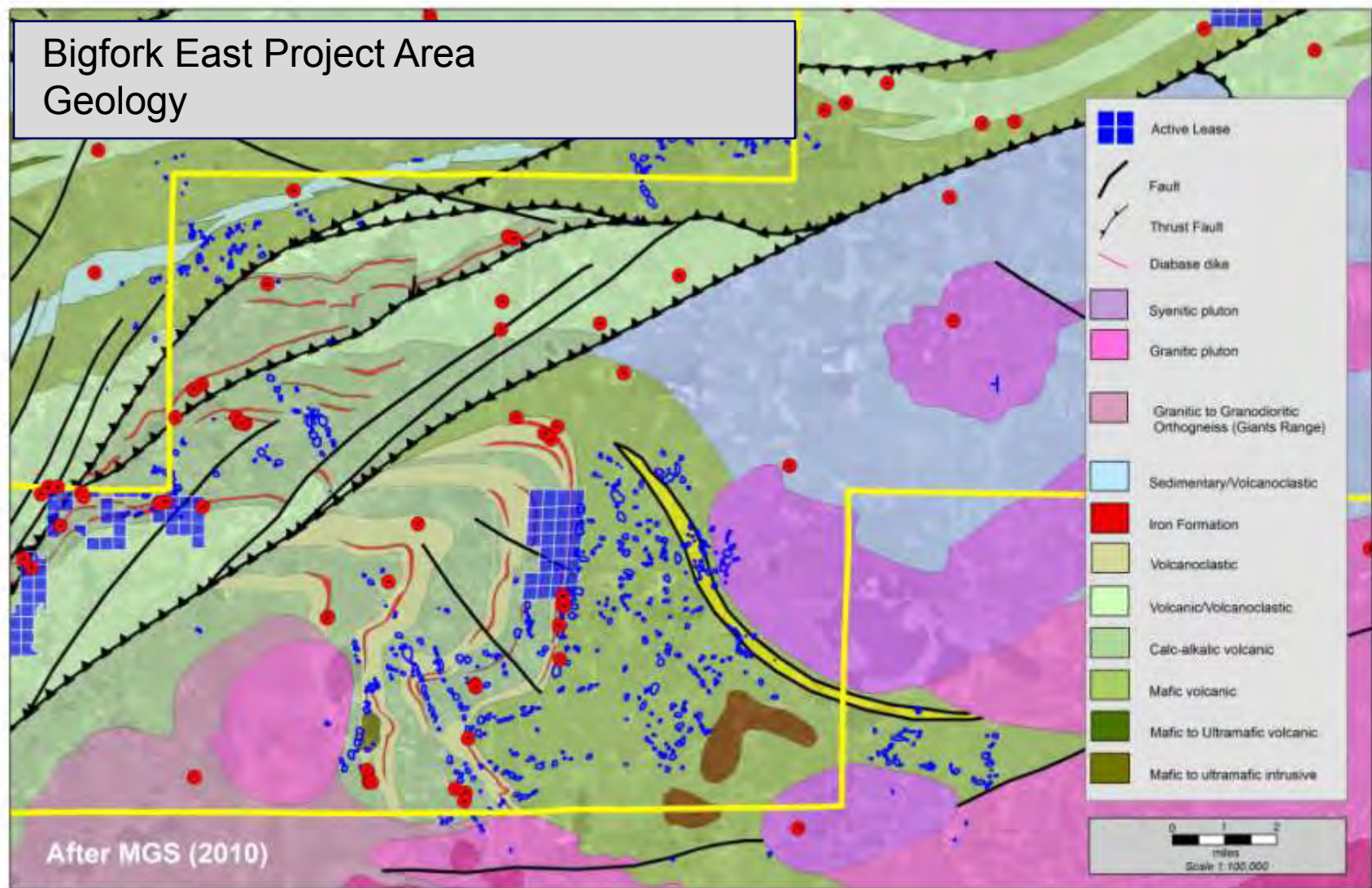
## Bigfork East Project Area Geology



Outcrops within the Bigfork East Project Area are also primarily located within the Archean metavolcanic and volcanoclastic rock units.

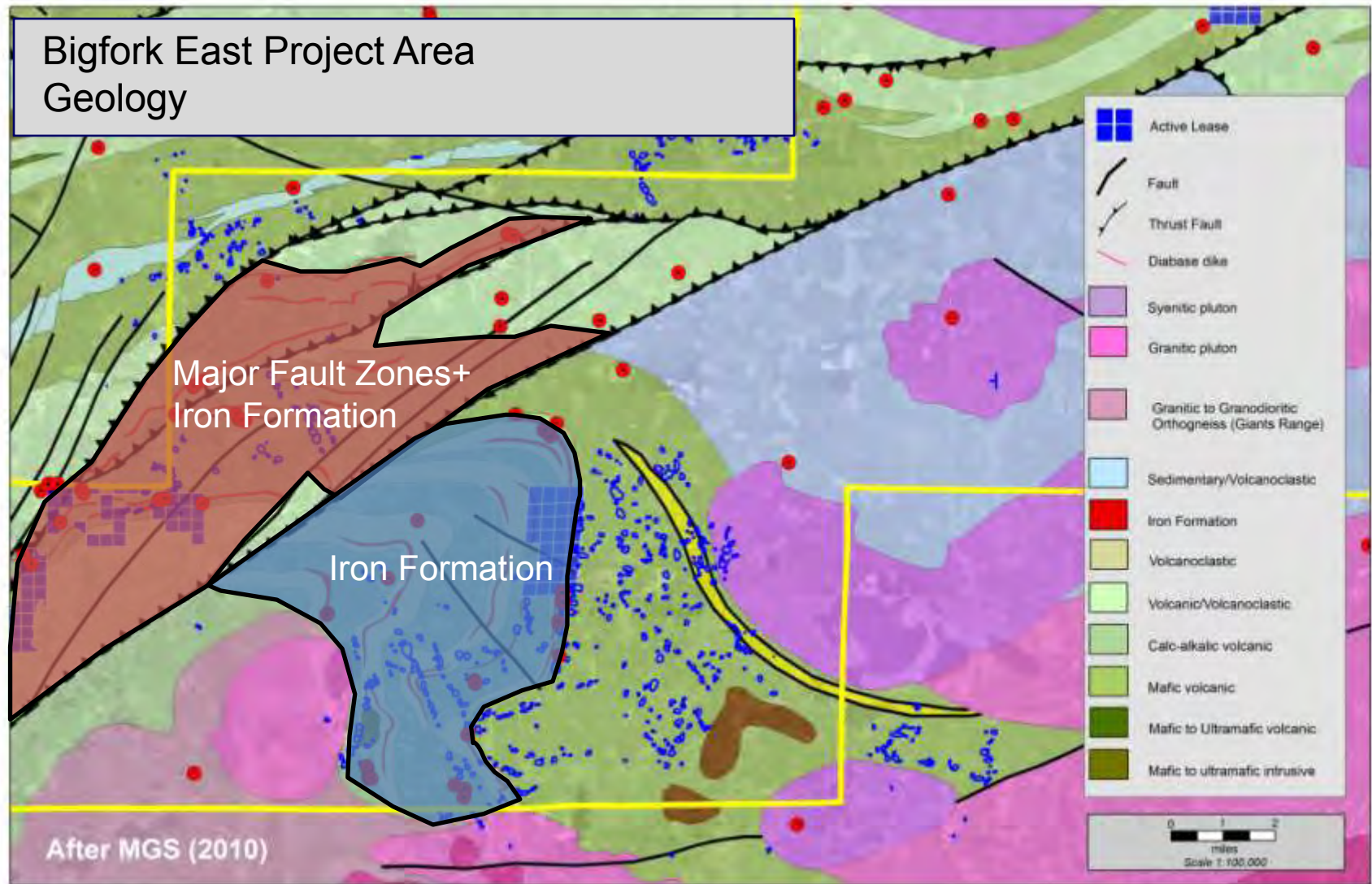


## Bigfork East Project Area Geology



The locations of historic exploratory borings in the Bigfork East Project Area are good proxy indicators for where mineral exploration programs have focused in the past.

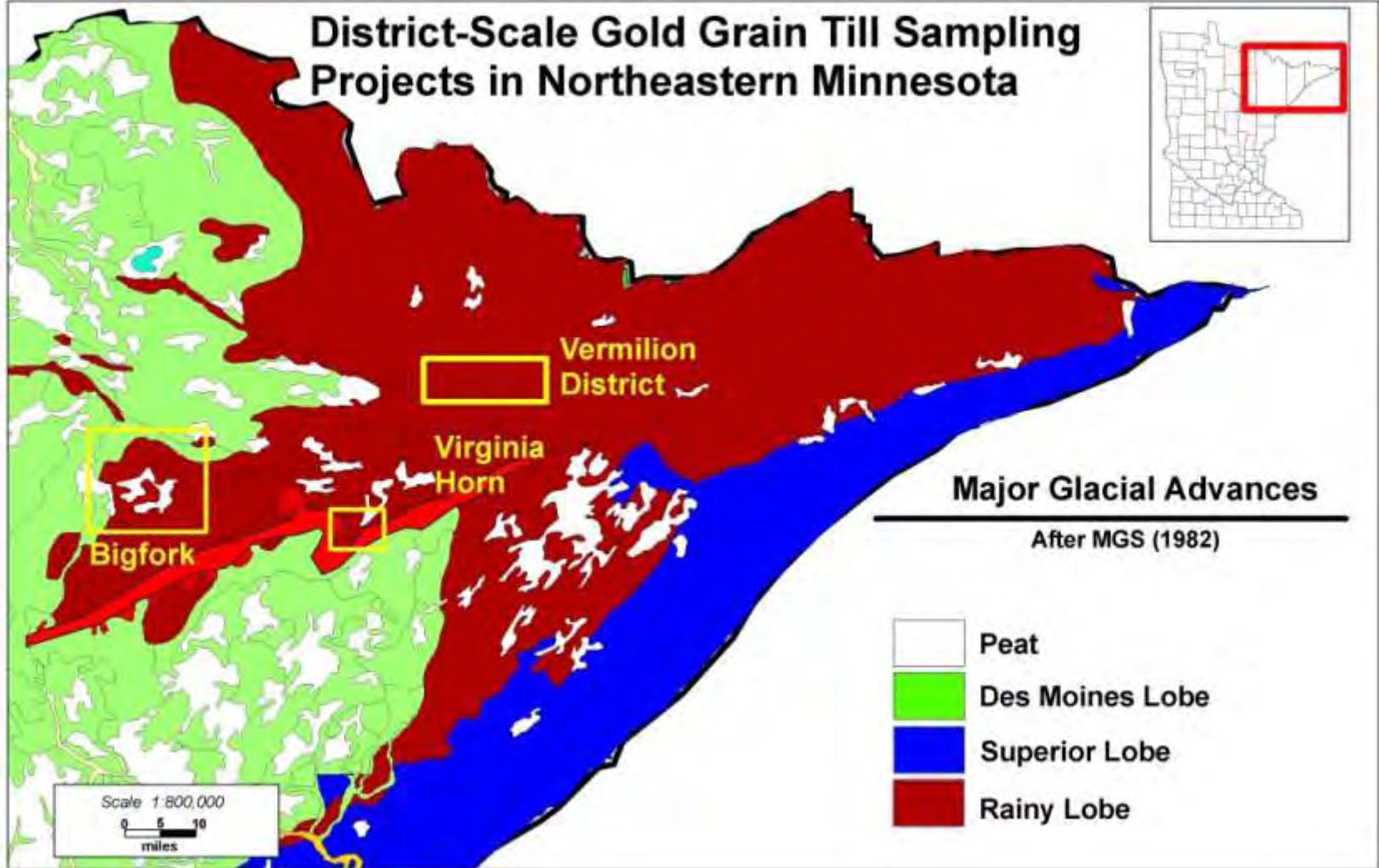
# Bigfork East Project Area Geology



Previous mineral exploration programs on State lands within the Bigfork East Project Area have focused on areas with discontinuous layers what Jirsa and Chandler (MGS Map M-176, 2007) describe as a “chert-, magnetite-, hematite-, and locally sulfide-bearing iron formation”.

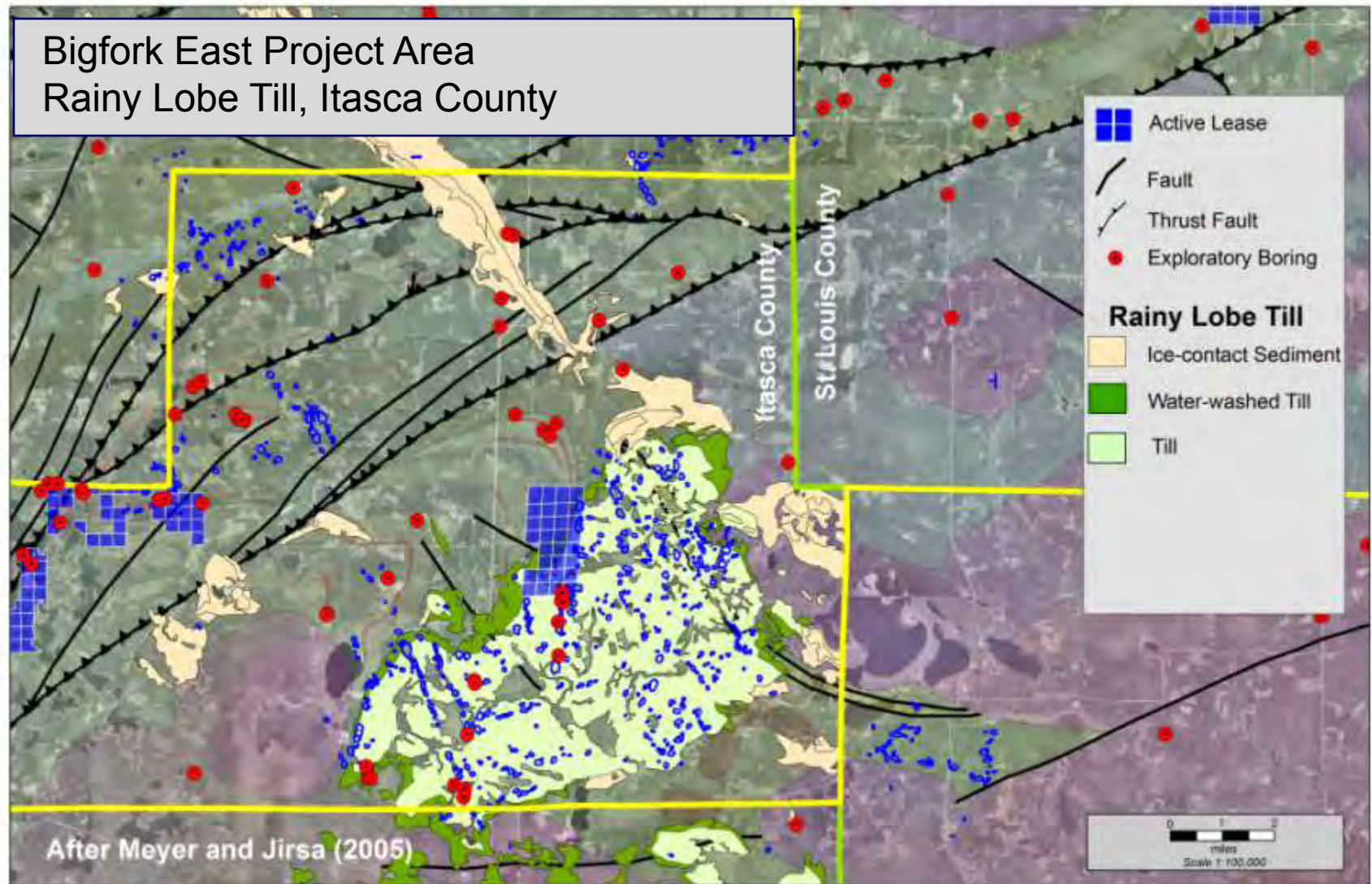


## District-Scale Gold Grain Till Sampling Projects in Northeastern Minnesota



The Bigfork Project Area is located on the contact between Rainy Lobe and younger Des Moines Lobe surficial sediments. The Rainy Lobe till also overlies shallow bedrock exposures in the Vermilion District and Virginia Horn.

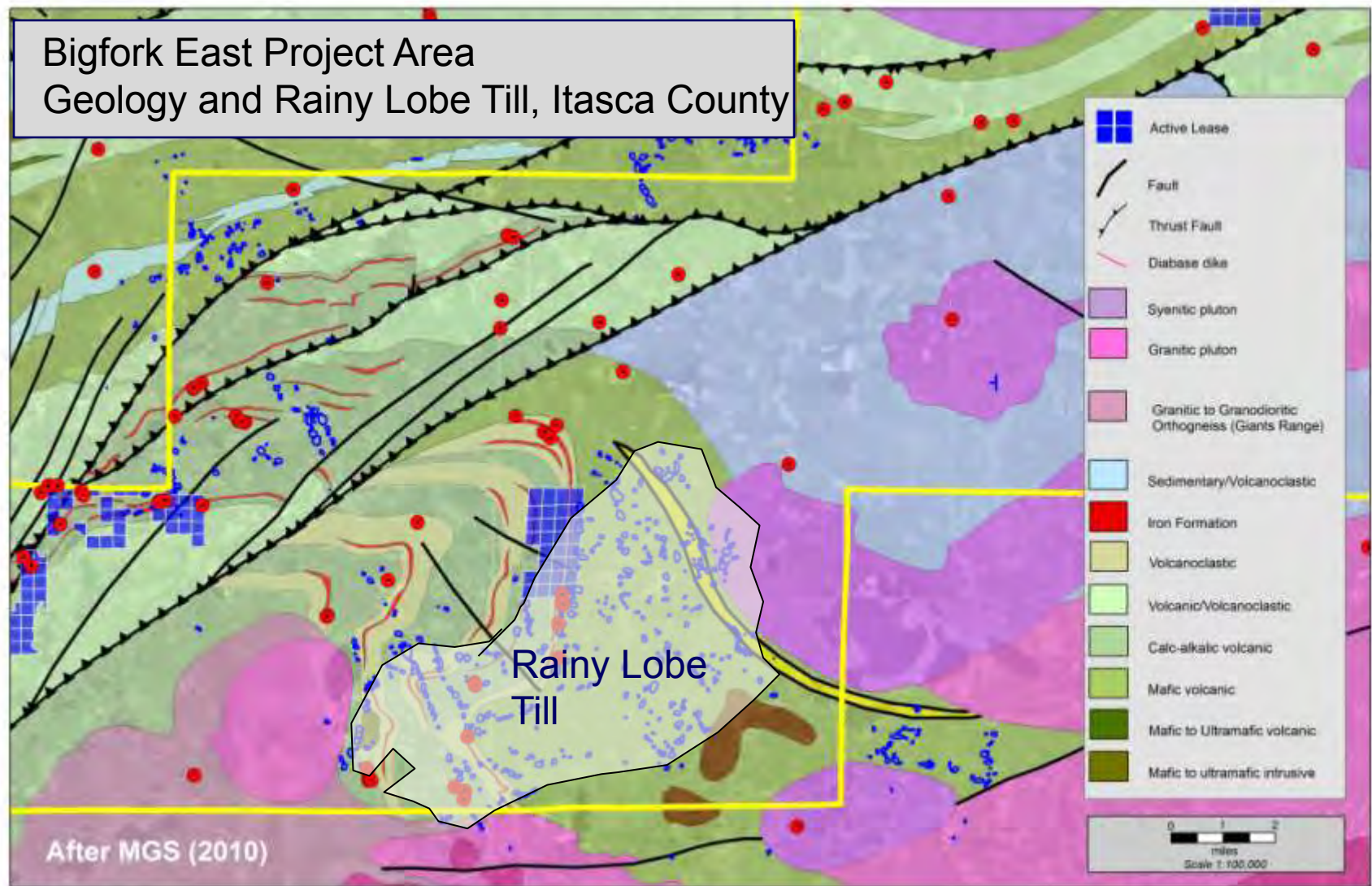
## Bigfork East Project Area Rainy Lobe Till, Itasca County



Rainy Lobe Till deposits are exposed over a portion of the Bigfork East Project. The till unit is generally found in thin layers of overburden over shallow bedrock exposures.



# Bigfork East Project Area Geology and Rainy Lobe Till, Itasca County



Areas in the Bigfork East Project Area where Rainy Lobe till deposits overlie Archean greenstone Bedrock were good candidates for an exploratory survey of gold grain counts in till.

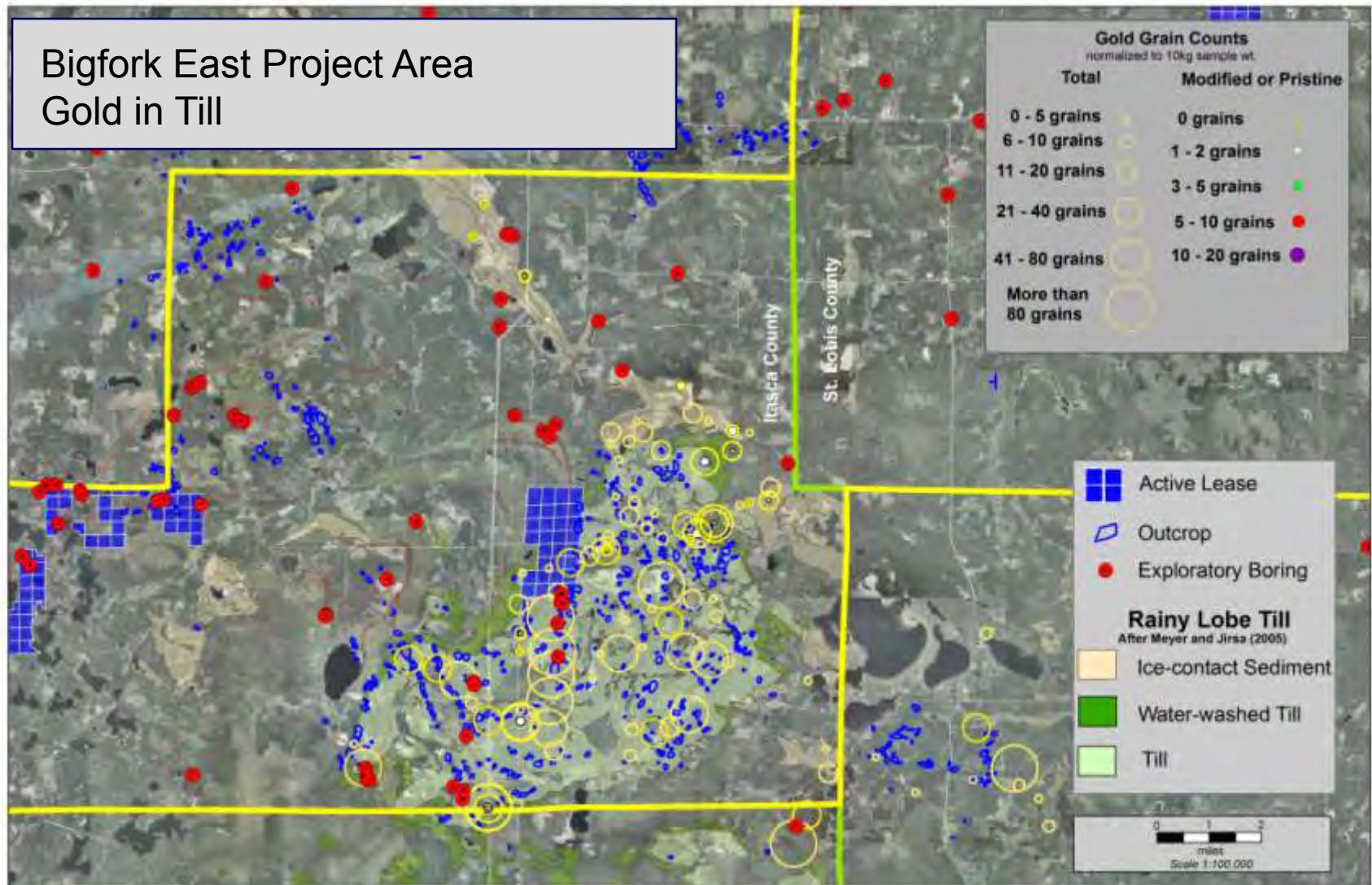
# Till Sampling



Samples of Rainy Lobe Till were collected on State Lands within the Bigfork East Project Area. All sample locations were accessible using a four-wheel drive truck or ATV. Samples were collected either by hand shovel or excavator. A mechanical excavator was used to open ten temporary test pits within the project area.



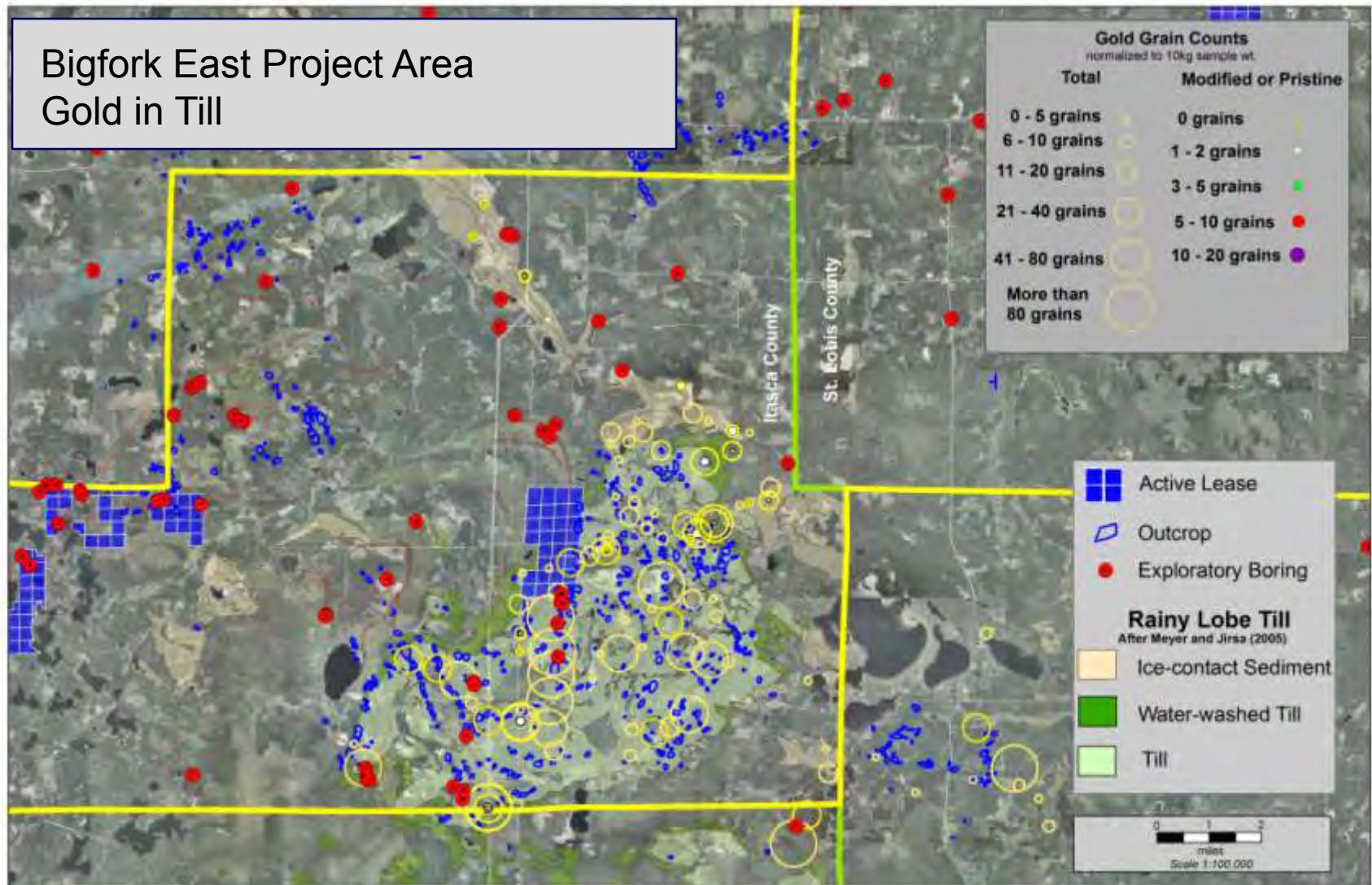
## Bigfork East Project Area Gold in Till



This map shows the distribution of till samples collected by the MnDNR and analyzed by Overburden Drilling Management, Ltd, for gold grain counts in till. A total of 133 samples have been collected in the Bigfork East and Calumet Project Areas.



## Bigfork East Project Area Gold in Till



Fifty-five (55) of the 133 samples in the Bigfork East Project Area have total gold grain counts above 10 (normalized to 10kg sample weight). The anomalously high gold grain counts are distributed over a wide area, making the Bigfork East Project area the largest cluster of high gold grain counts in Minnesota.

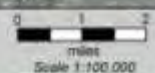
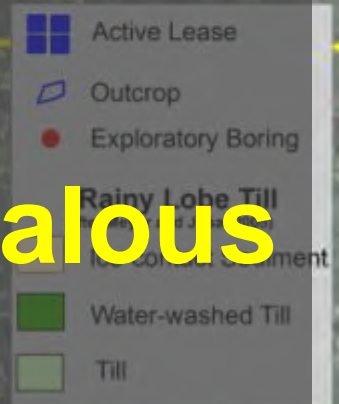
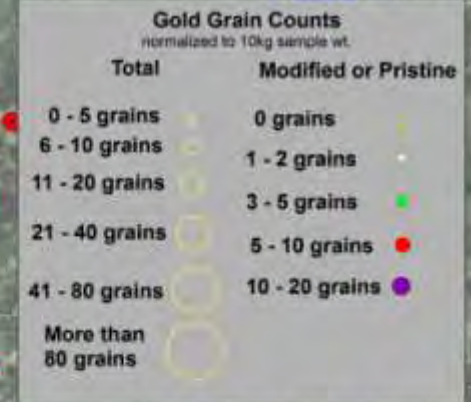


## Bigfork East Project Area Gold in Till

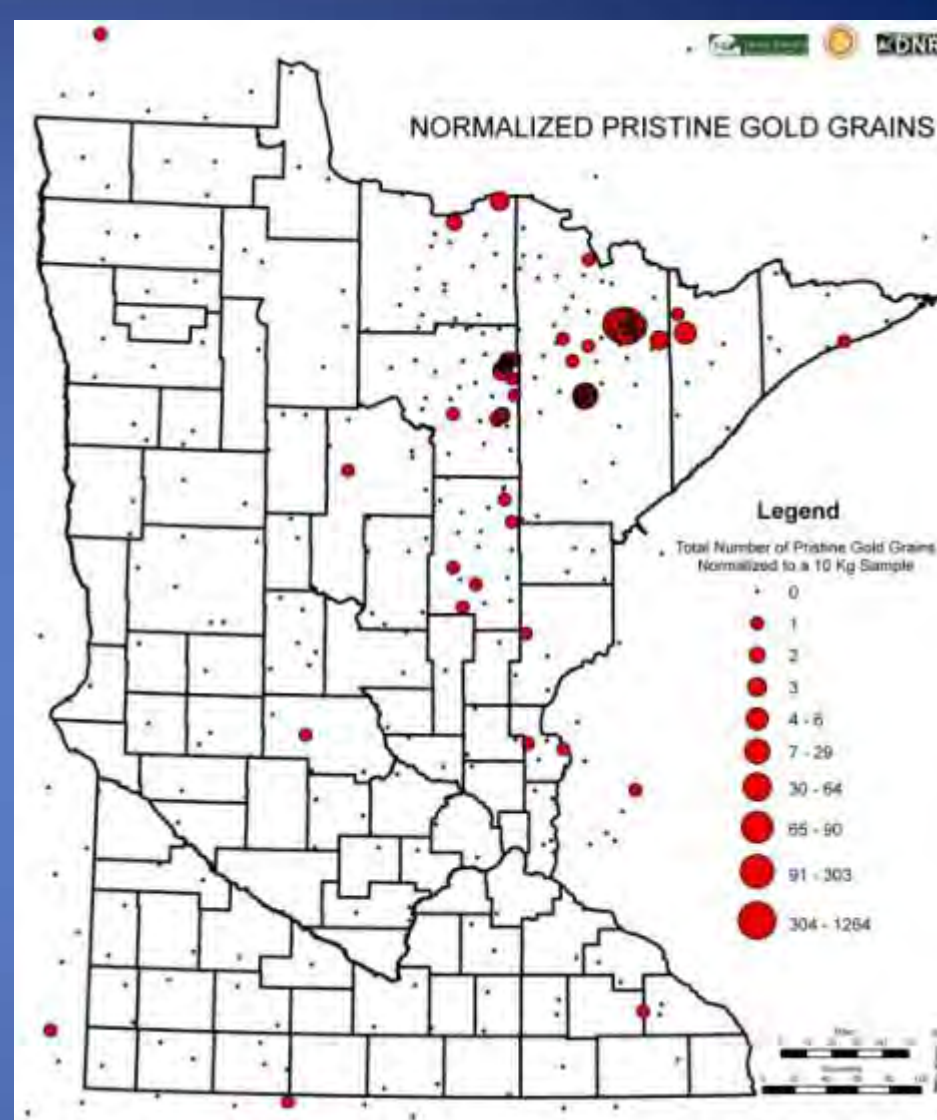
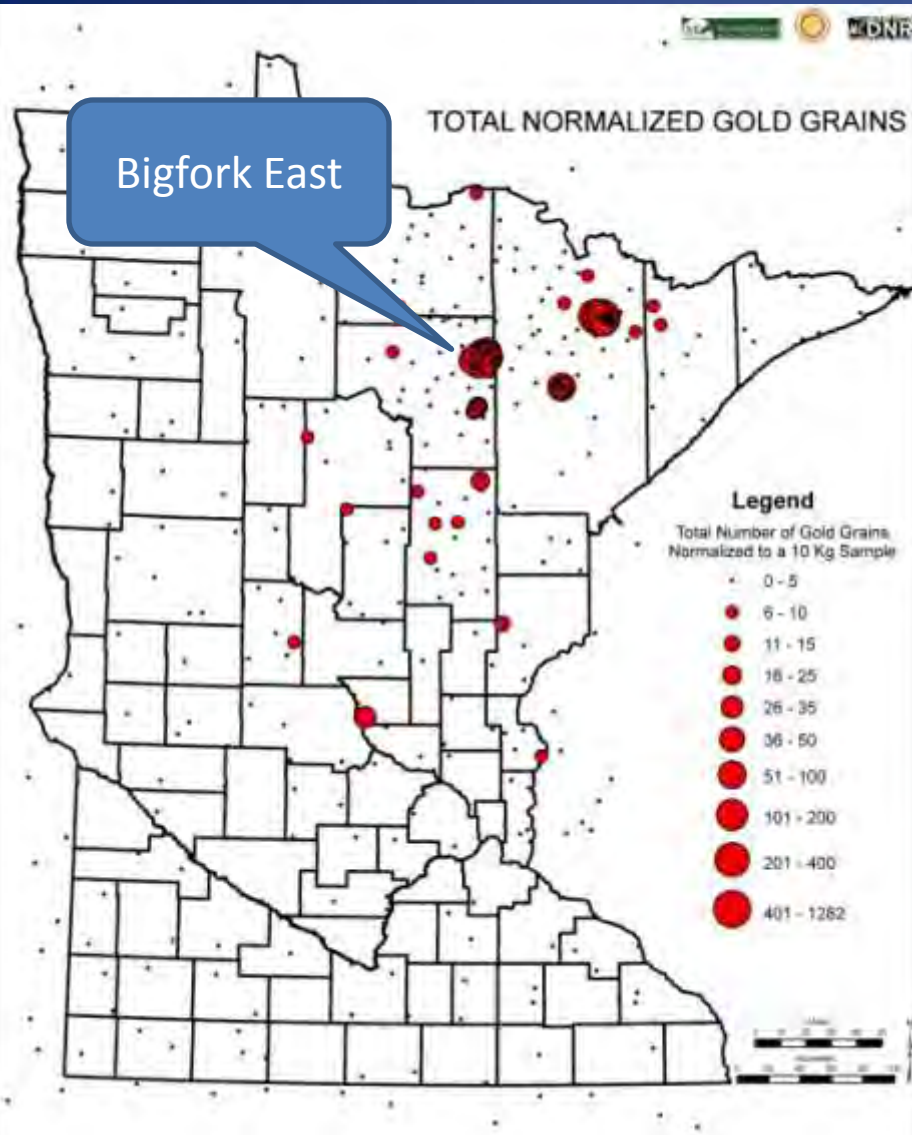
**n = 133**

**55 with >10 grains**

**Largest cluster of anomalous  
gold in till in MN**



Fifty-five (55) of the 133 samples in the Bigfork East Project Area have total gold grain counts above 10 (normalized to 10kg sample weight). The anomalously high gold grain counts are distributed over a wide area, making the Bigfork East Project area the largest cluster of high gold grain counts in Minnesota.



These state-wide maps show the distribution of till samples collected by the MnDNR, Minnesota Geological Survey, and other organizations. The Bigfork East Project Area has high total gold grain counts, but relatively modest counts of pristine gold grains.



## Gold Grain Morphology

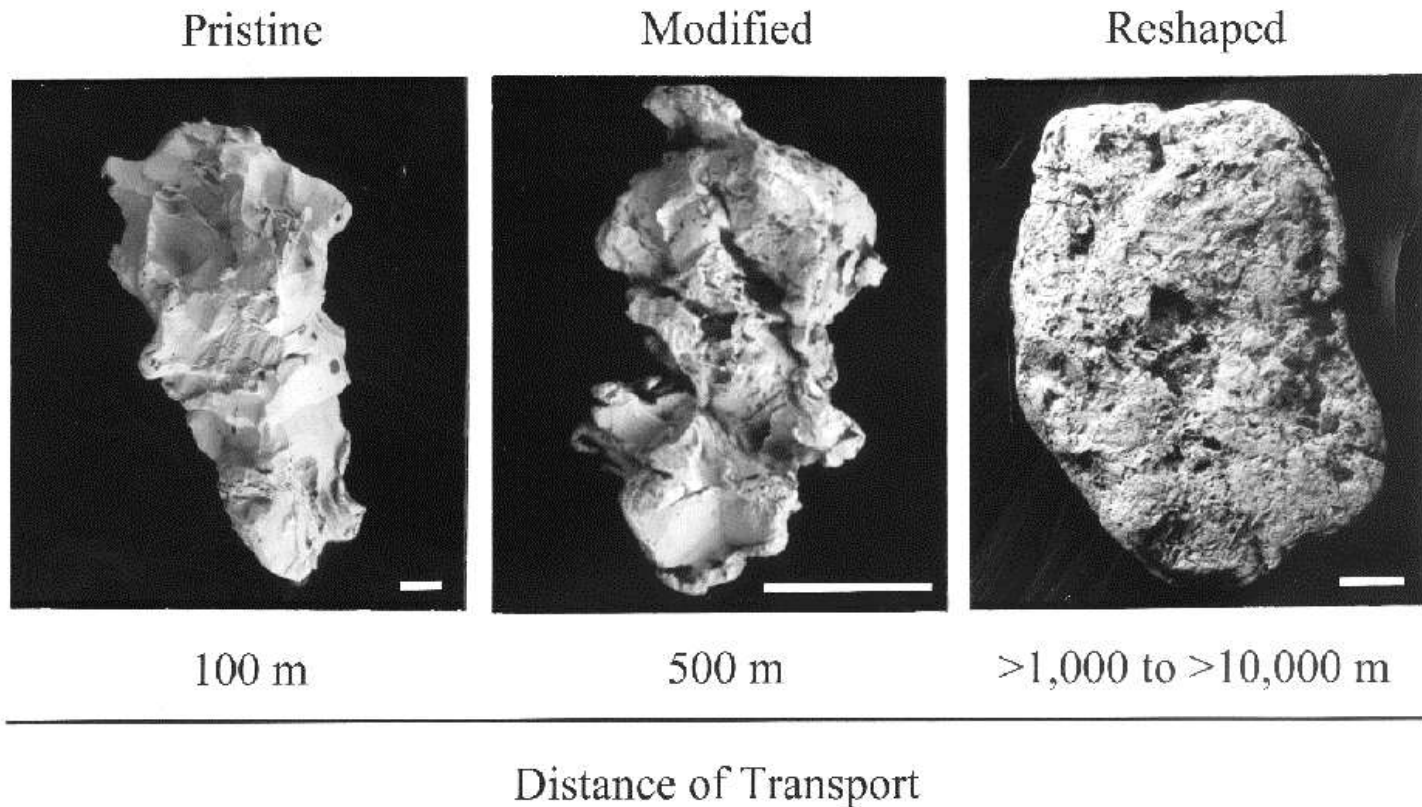
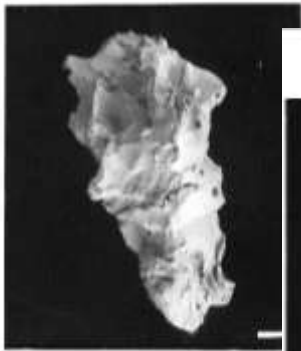


Figure from ODM, Ltd.

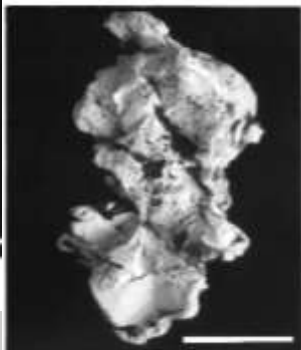
Gold grain morphology is a key indicator for proximal bedrock gold mineralization. “Pristine” gold grains, with sharp grain boundaries, have traveled less than 100 m from its bedrock source. As source distance increases, the gold grains become completely reshaped.

Pristine



100 m

Modified

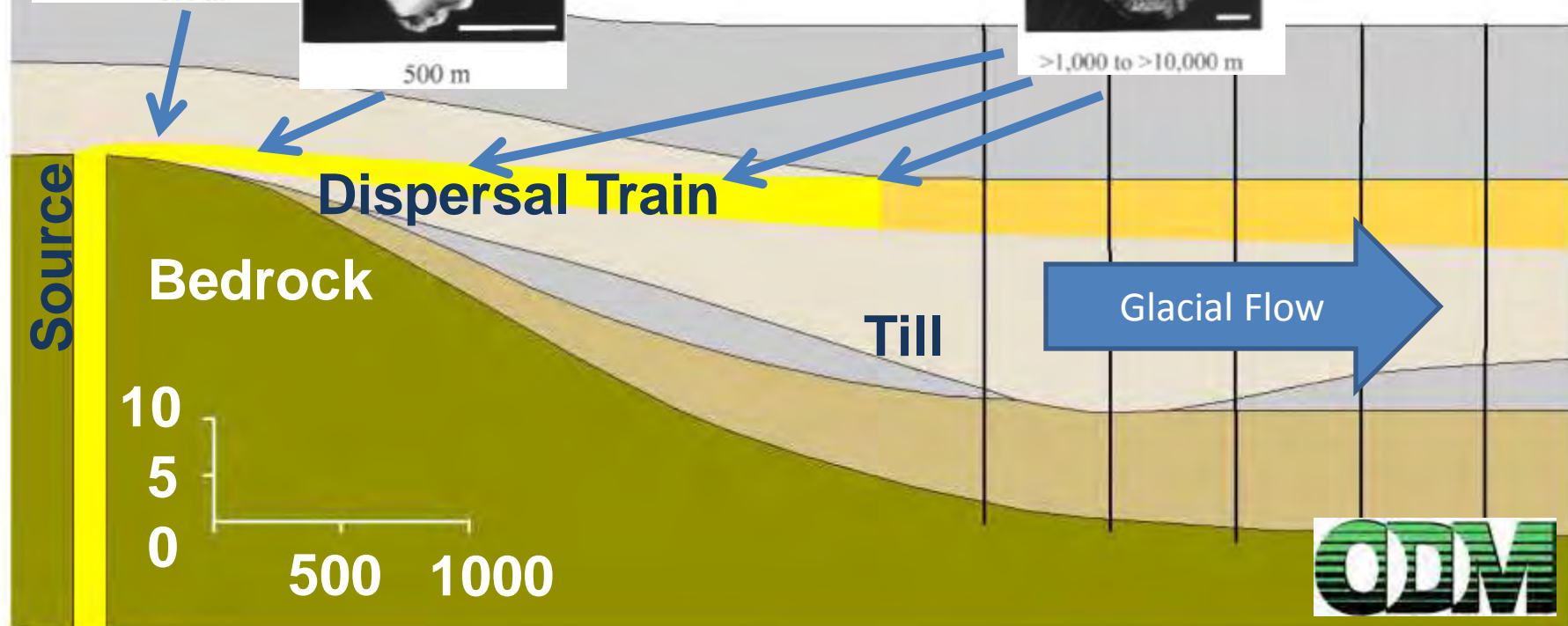


500 m

Reshaped



>1,000 to >10,000 m



As the distance to bedrock gold source increases, the number of gold grain counts decreases due to dispersion. High gold grain counts are typically linked to proximal sources; beyond a few thousand meters, total gold grain counts drop below “background” concentrations (i.e. less than 10 total grains/10kg sample).



# December 2009 ODM Letter Report



- Gold grain counts are very high

- Almost all of the gold grains are reshaped

- Many gold grains are flattened, and have thicker rims

That the Bigfork East project area has high gold grain counts consisting of almost exclusively reshaped grains indicates that there must have been more than a simple, one-stage deposition process. ODM noted this complexity in a December 2009 letter report.



# Possible two-stage process

- Concentration within proglacial paleoplacer beach deposit
- Remobilization by overriding glacier, incorporation into till



ODM proposed that the rounded, “toroidal” gold grains morphologies were created in a paleoplacer beach environment, perhaps in a proglacial lake. A readvancing ice sheet could have remobilized these paleoplacer gold grains, and incorporated them into a till deposit.





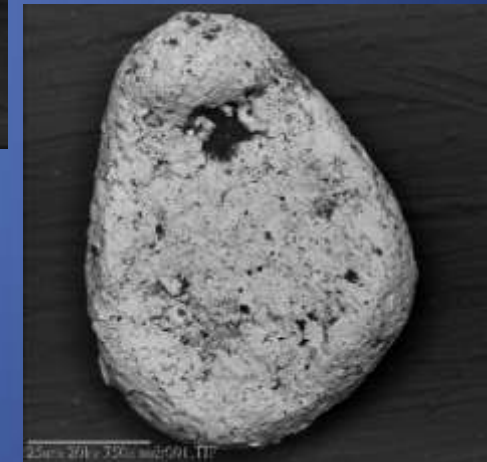
BF-41



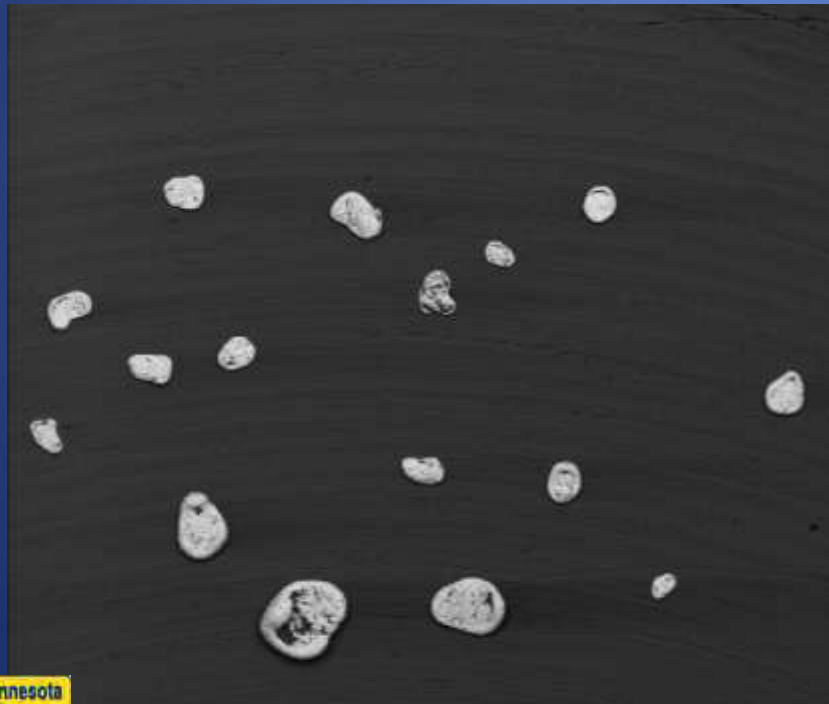
25um 20kv 1.2k x mag062.tif



25um 20kv 1.2k x mag062.tif



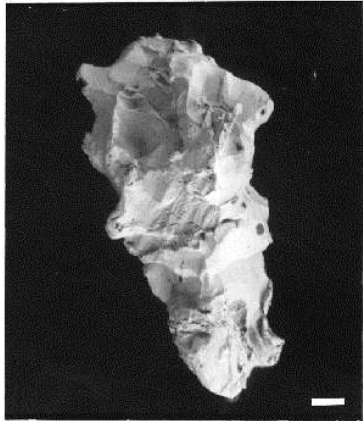
25um 20kv 1.2k x mag062.tif



The MnDNR asked ODM to examine individual gold grains from high count samples in the Bigfork East project area. ODM chose sample BF-41 as representative, and examined these gold grains with an SEM.

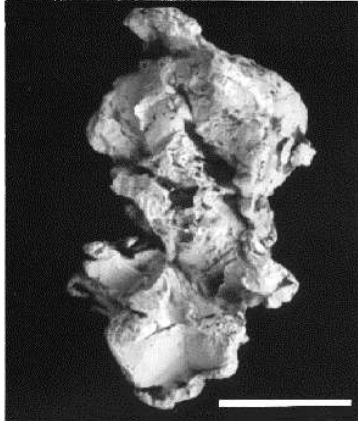
## Gold Grain Morphology

Pristine



100 m

Modified



500 m

Reshaped



>1,000 to >10,000 m

Distance of Transport

Typical gold grain  
morphologies  
in Superior Province till

*Bigfork East Sample BF-41*



“toroidal or Semi-toroidal  
Forms” in Bigfork East gold grains

Many of the gold grains from the Bigfork East Project Area have atypical “toroidal” morphologies. These grains are flattened, rounded, and have thicker, donut-shaped rims.



# June 2010 ODM Letter Report



- Gold grains in the highest total samples are almost all toroidal
- Gold grains are 1000 fineness...alloyed silver leached out
- Need hundreds of thousands or millions of years to leach the Ag

ODM reported that the gold grains examined under SEM have 1000 fine pure gold rims, indicating that alloyed silver had leached out of these rims. ODM suggests that hundreds of thousands or millions of years would be required to leach this silver out of the gold grains.

# Possible two-stage process

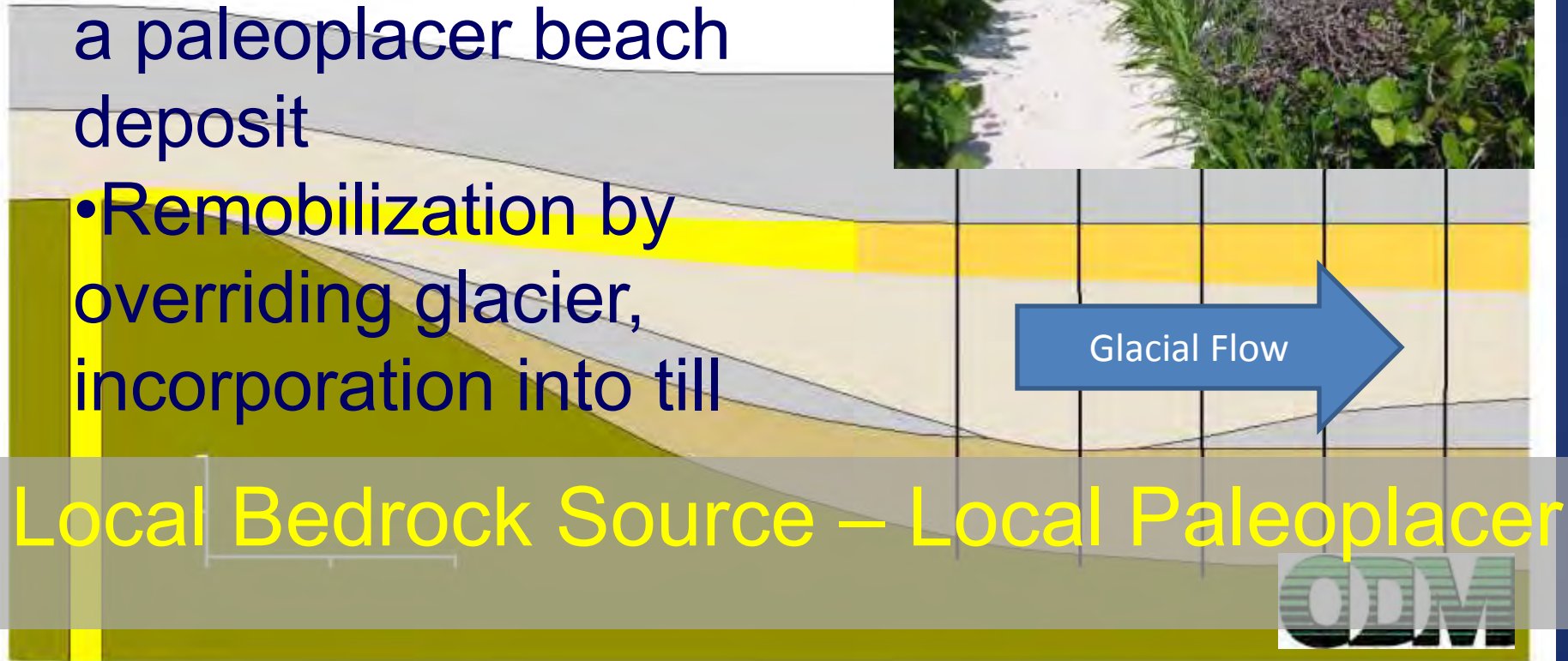
- Concentration within a **paleo**placer beach deposit
- Remobilization by overriding glacier, incorporation into till



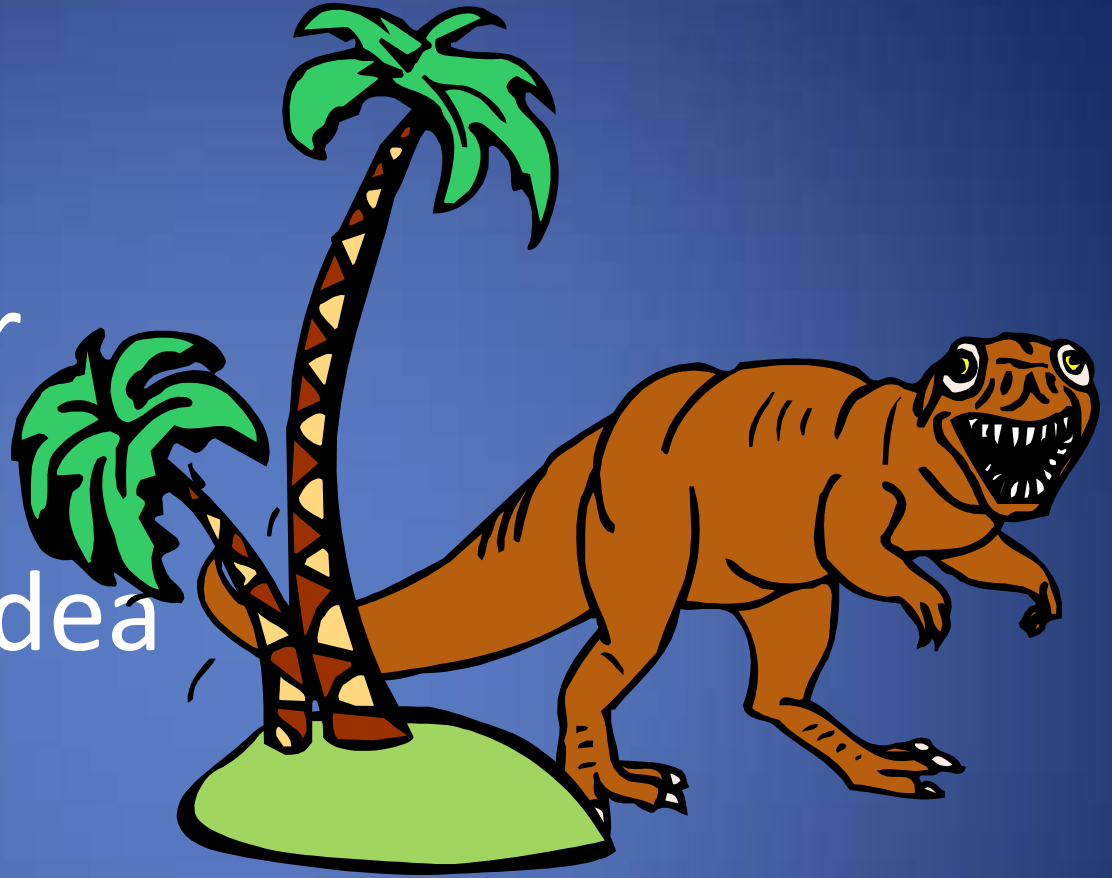


# Possible two-stage process

- Concentration within a paleoplacer beach deposit
- Remobilization by overriding glacier, incorporation into till



Is there other  
evidence to  
support the idea  
of a local  
bedrock gold  
source or  
paleoshoreline?





# Coleraine Formation

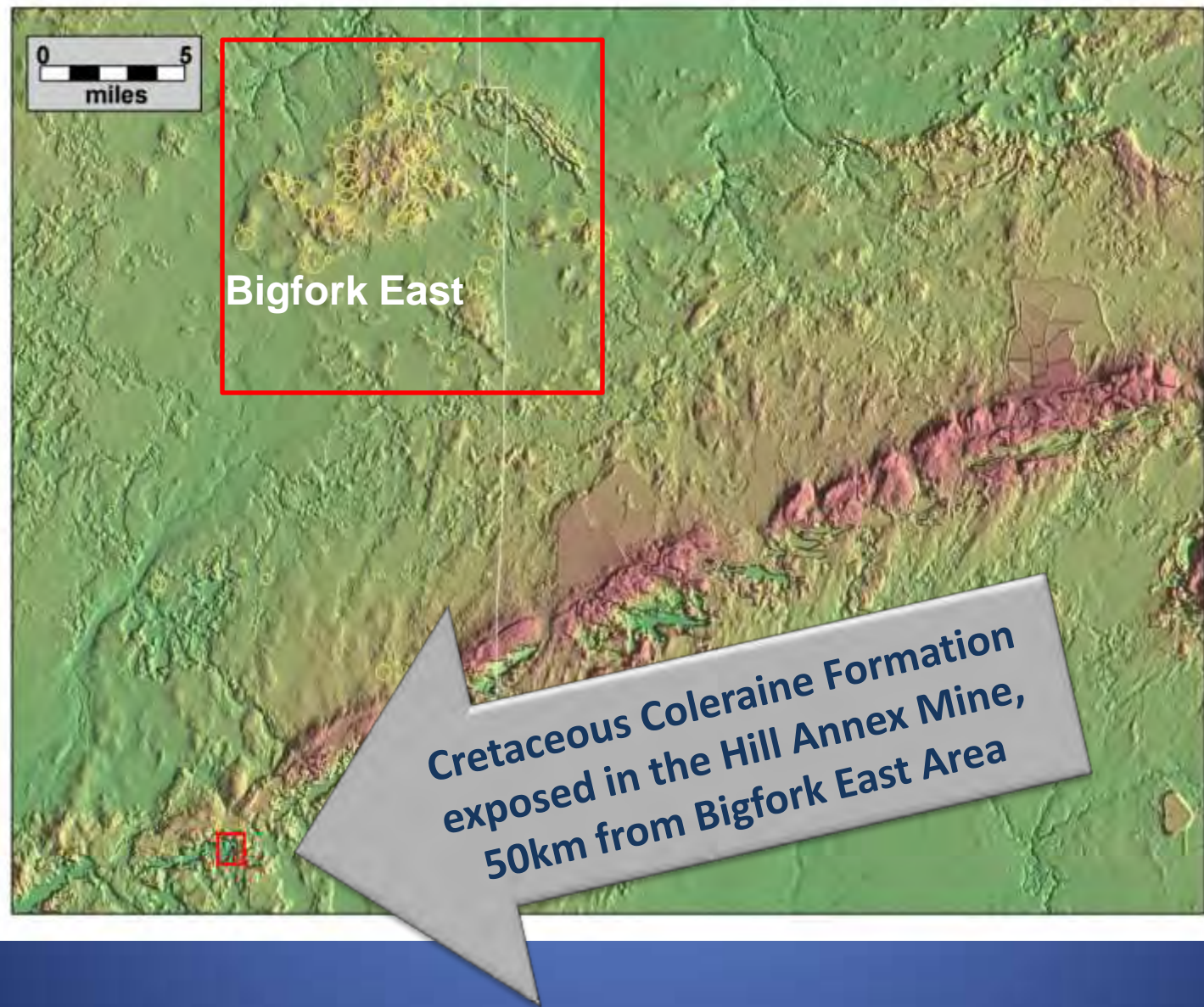


Cretaceous-era  
conglomerate



Cretaceous-Era conglomerates and other sedimentary rocks are exposed in Northern Minnesota, most prominently in open-mine pits associated with the Mesabi Iron Range. Sharks teeth and other fossil evidence suggest a beach or near-shore environment.





The Cretaceous-Era Coleraine Formation is exposed in the Hill Annex Mine, located only 50km from the Bigfork East Project Area.

# Hill Annex Mine



This picture shows the western pit wall of the Hill Annex Mine.



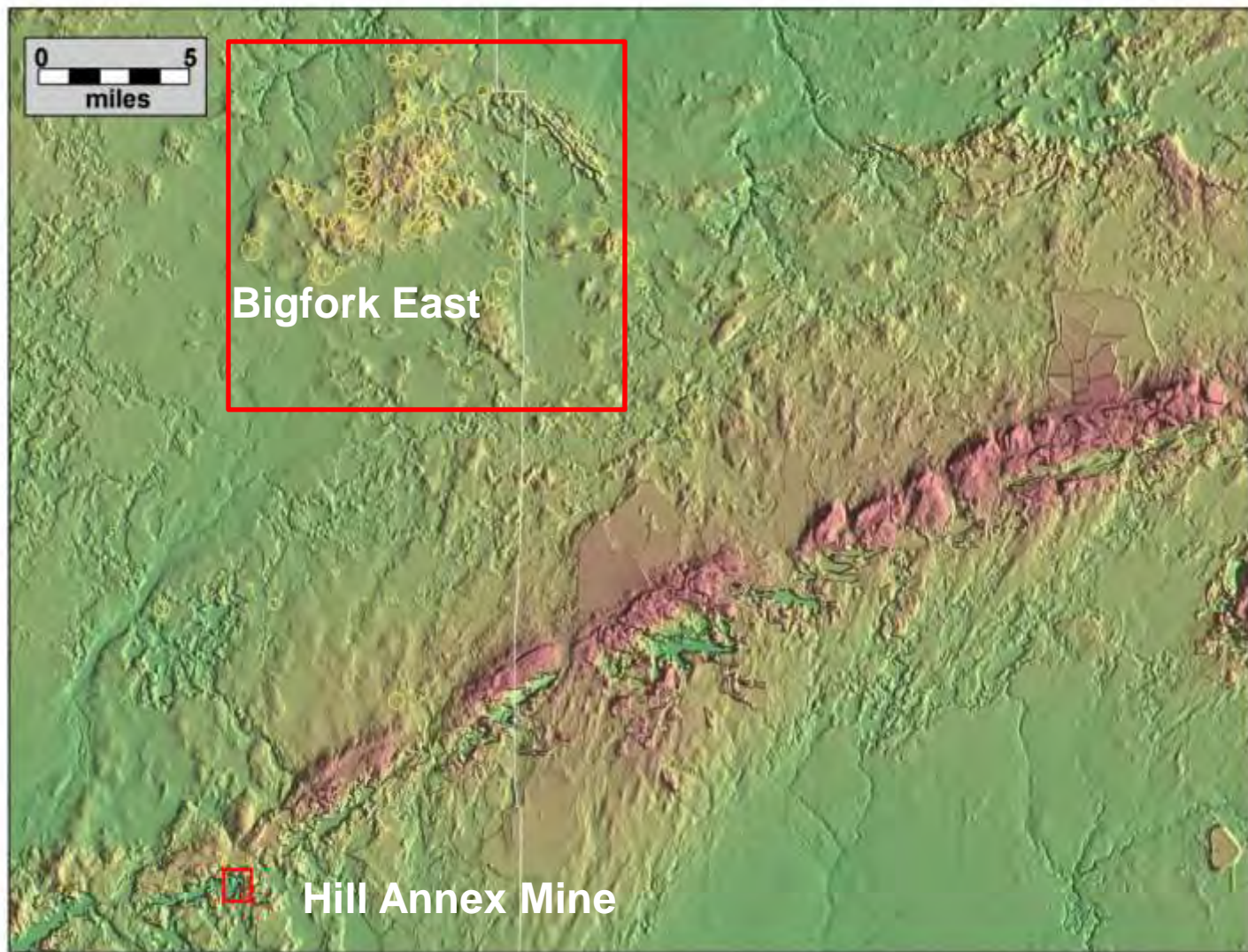
# Hill Annex Mine



The Cretaceous Coleraine Formation sits unconformably over the Biwabik Iron Formation.





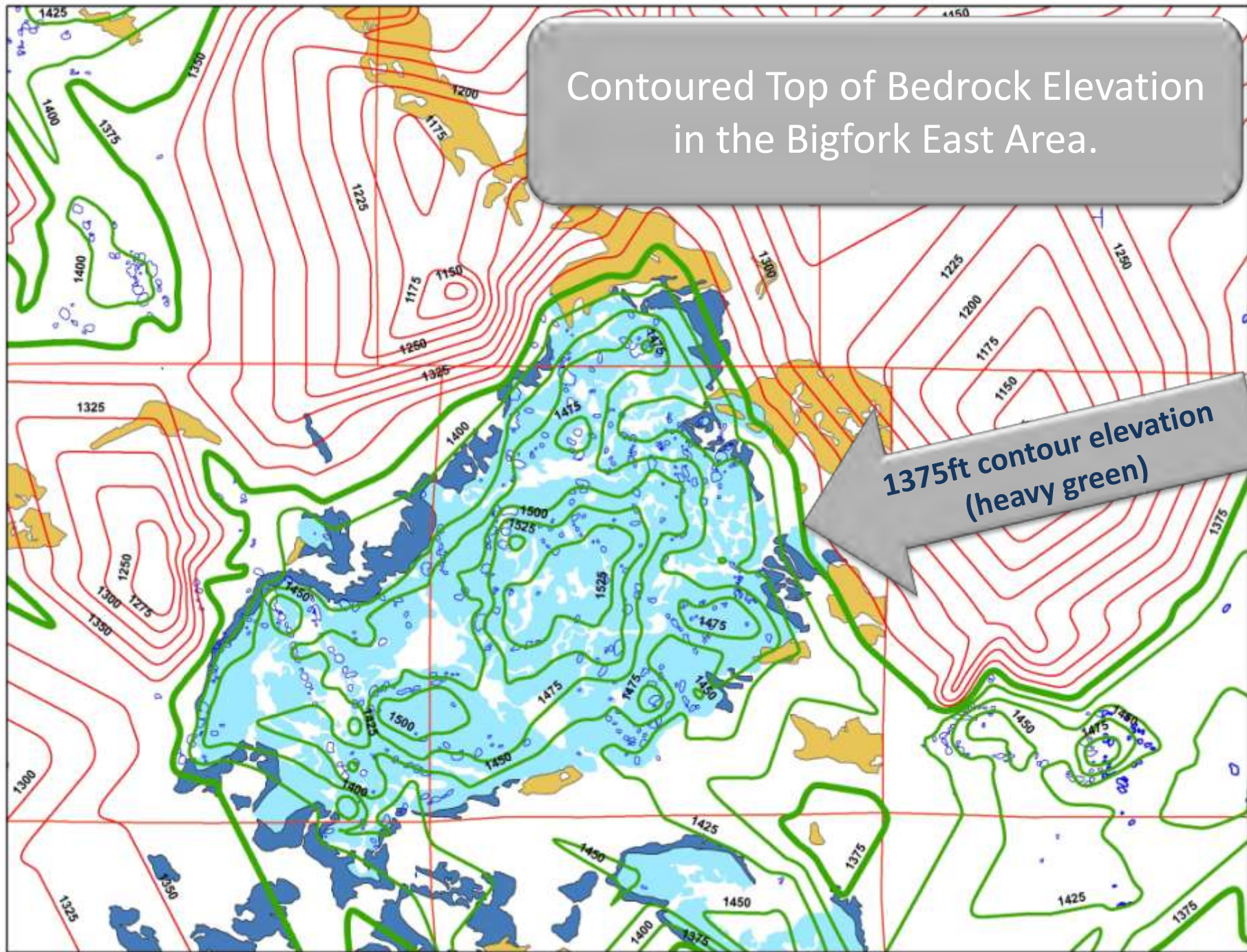


The Bigfork East Project Area and Hill Annex Mine sit on a geologically stable craton. Glacial rebound has created elevation changes, but given the relatively short distance the difference in rebound between the two areas is likely minimal.



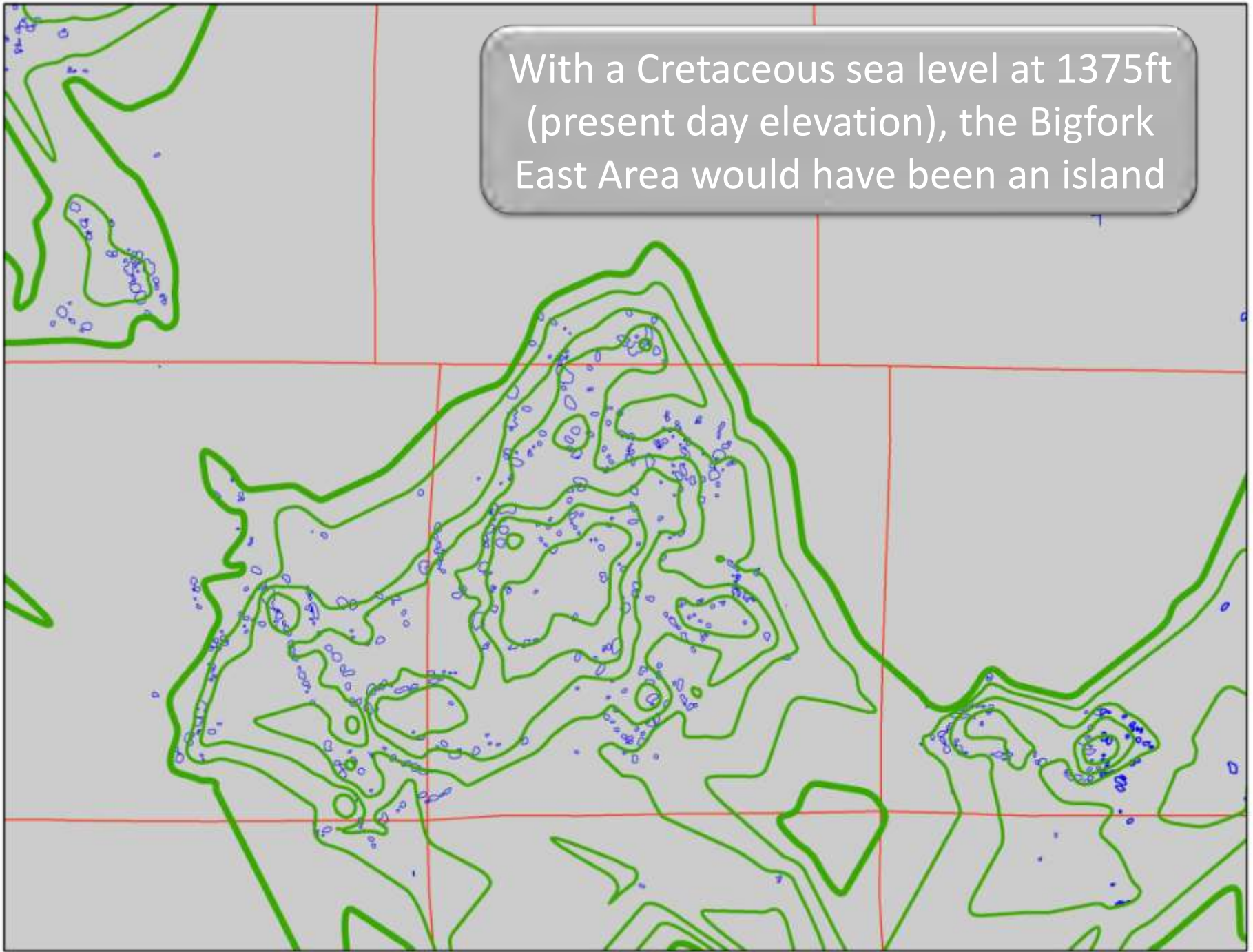
Contoured Top of Bedrock Elevation  
in the Bigfork East Area.

1375ft contour elevation  
(heavy green)

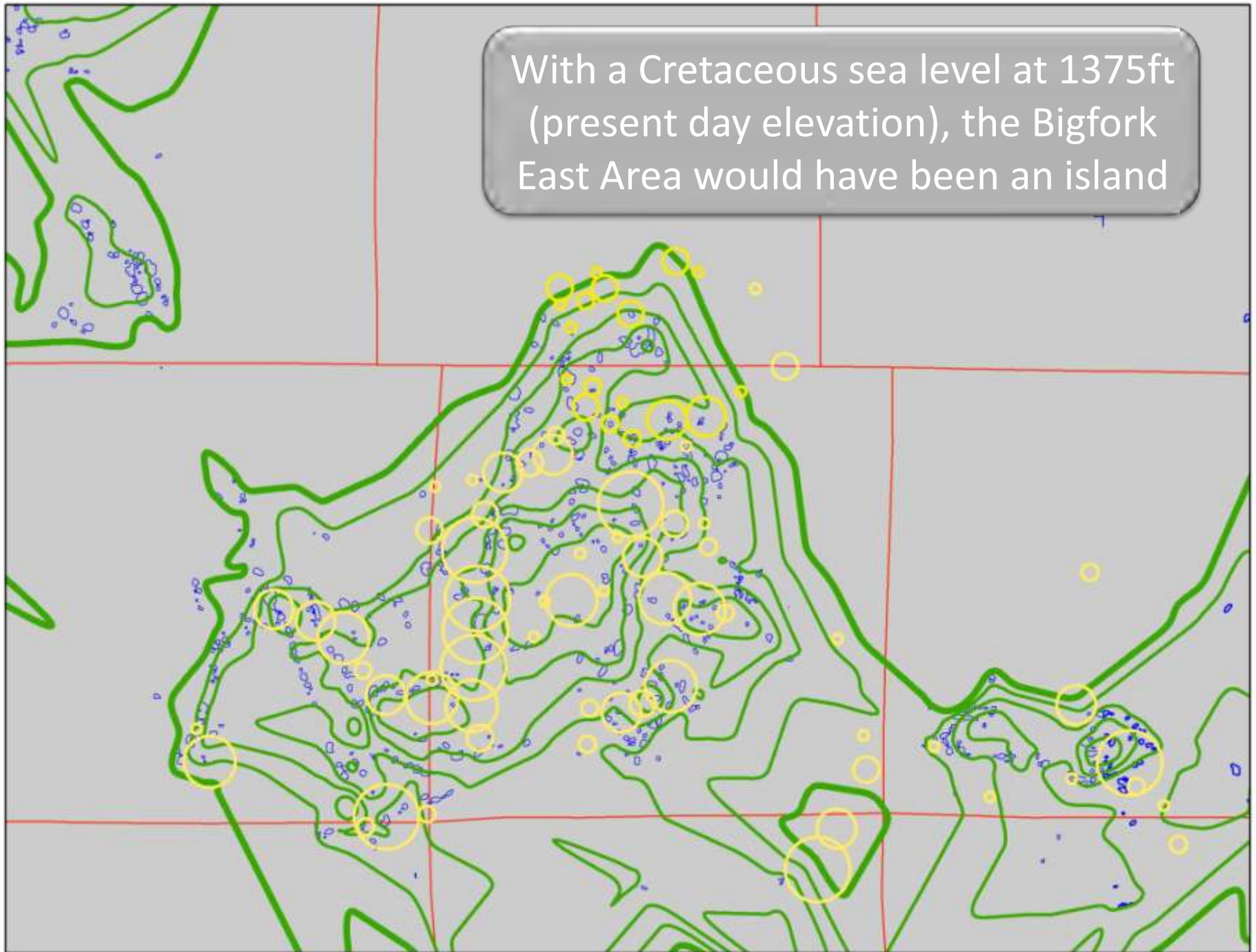




With a Cretaceous sea level at 1375ft  
(present day elevation), the Bigfork  
East Area would have been an island

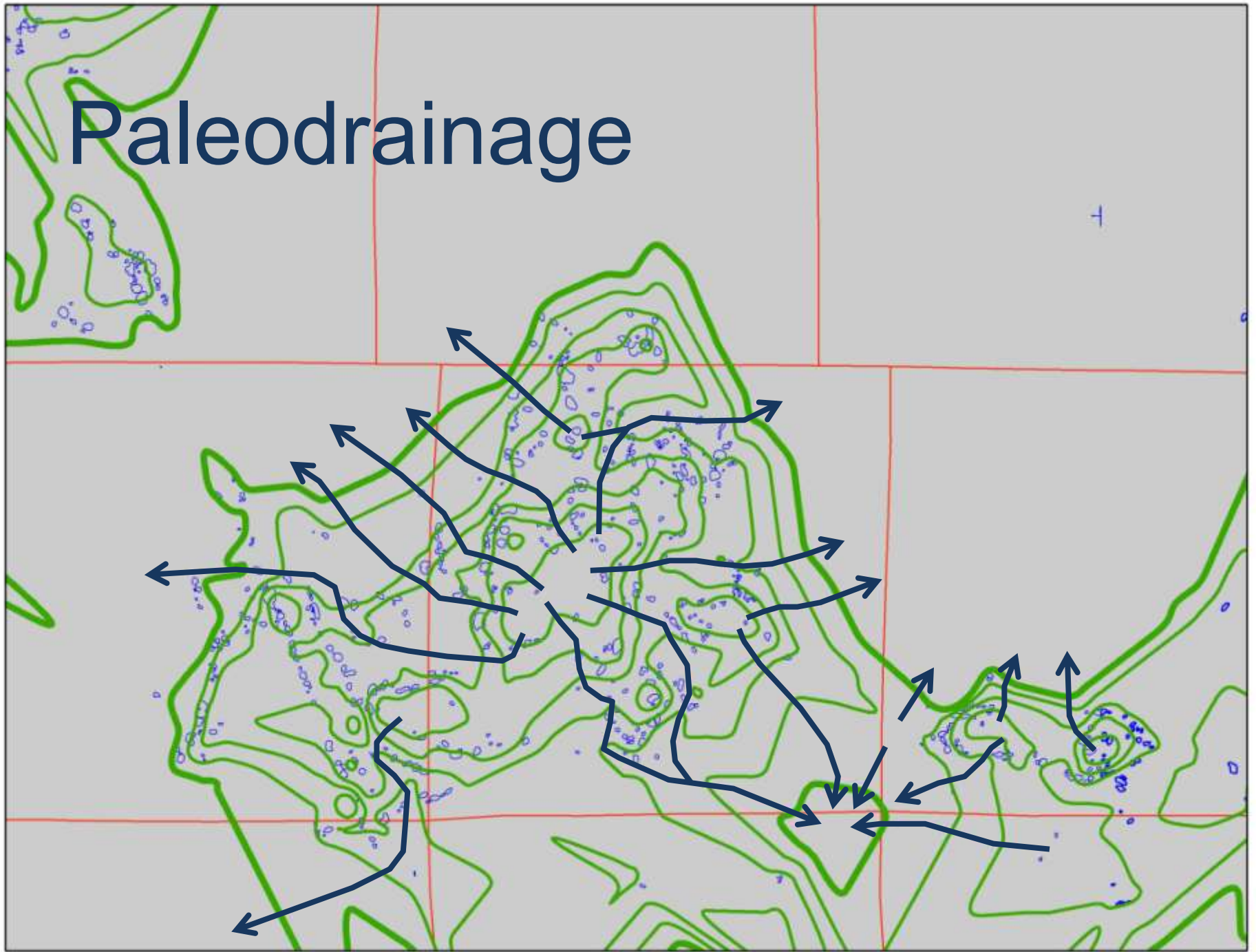


With a Cretaceous sea level at 1375ft  
(present day elevation), the Bigfork  
East Area would have been an island

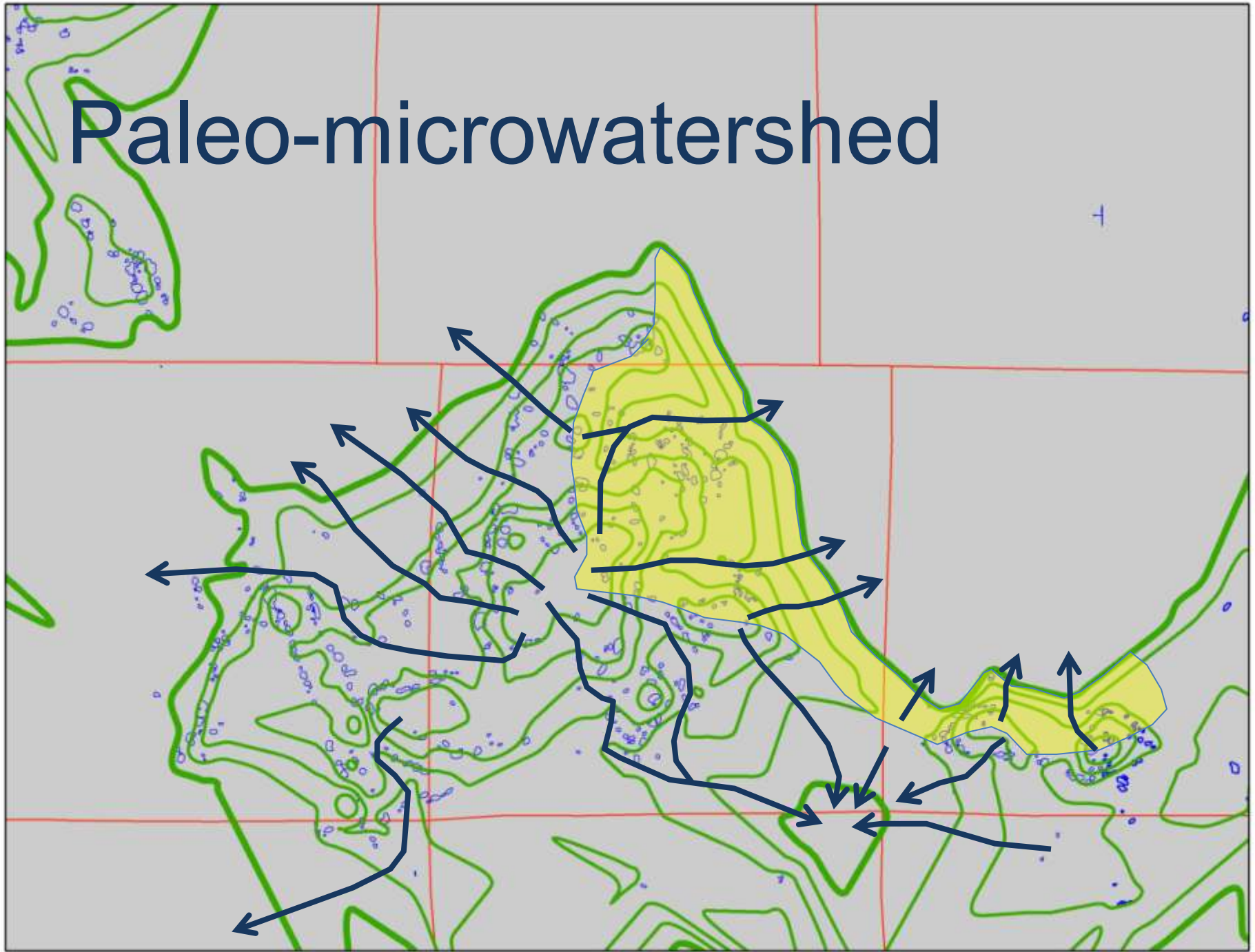




# Paleodrainage



# Paleo-microwatershed



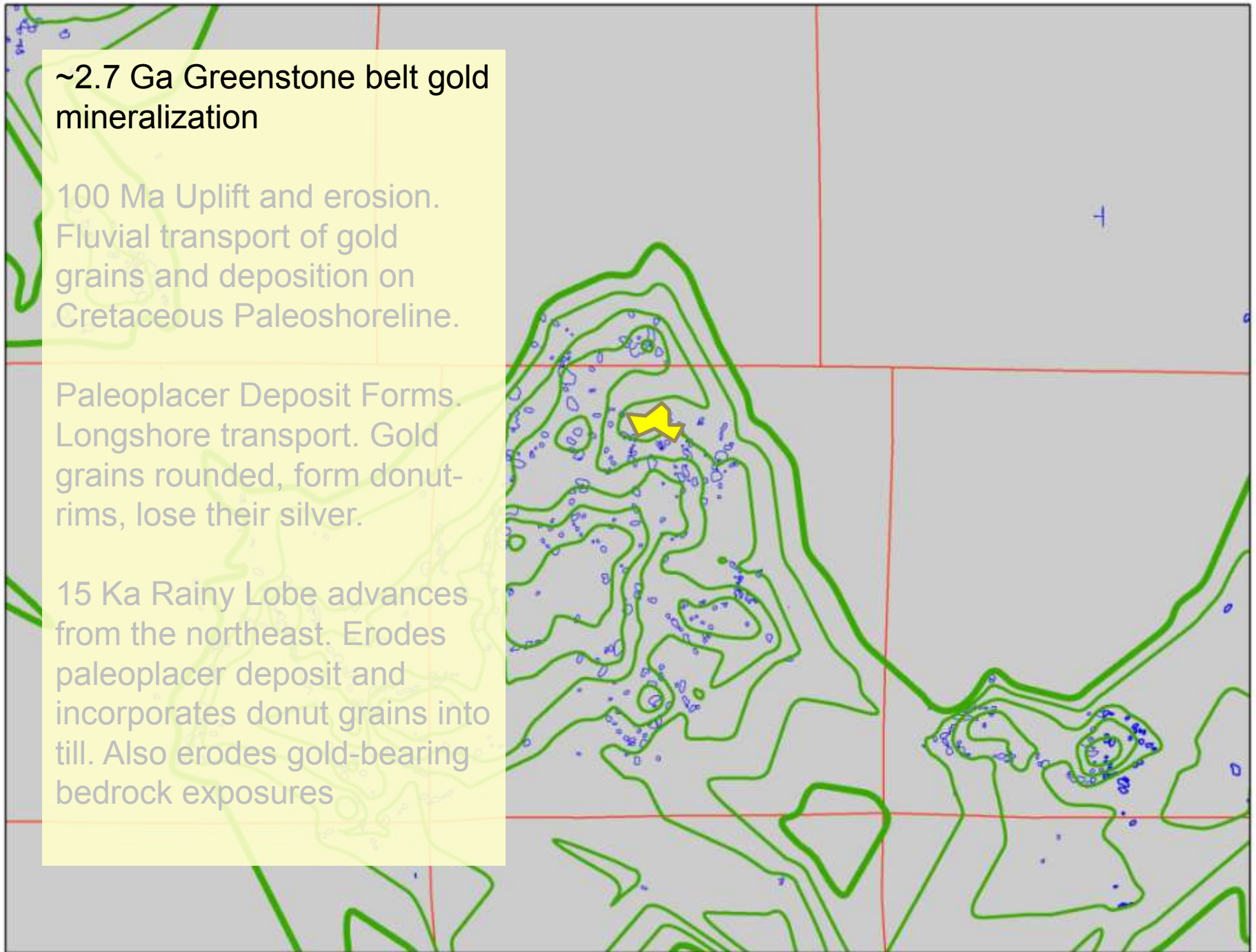


## ~2.7 Ga Greenstone belt gold mineralization

100 Ma Uplift and erosion.  
Fluvial transport of gold grains and deposition on Cretaceous Paleoshoreline.

Paleoplacer Deposit Forms.  
Longshore transport. Gold grains rounded, form donut-rims, lose their silver.

15 Ka Rainy Lobe advances from the northeast. Erodes paleoplacer deposit and incorporates donut grains into till. Also erodes gold-bearing bedrock exposures

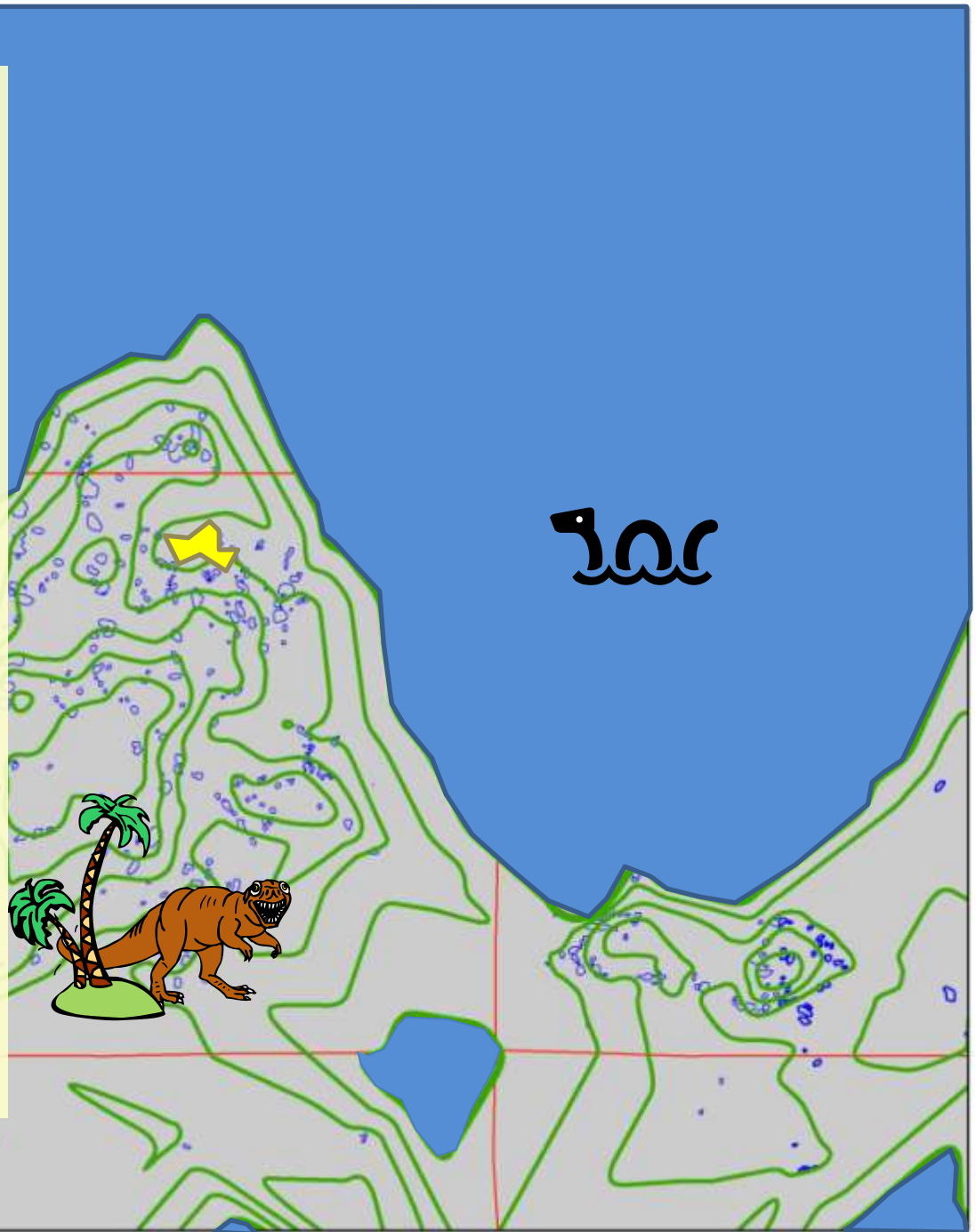


~2.7 Ga Greenstone belt gold mineralization

100 Ma Uplift and erosion.  
Fluvial transport of gold grains and deposition on Cretaceous Paleoshoreline.

Paleoplacer Deposit Forms.  
Longshore transport. Gold grains rounded, form donut-rims, lose their silver.

15 Ka Rainy Lobe advances from the northeast. Erodes paleoplacer deposit and incorporates donut grains into till. Also erodes gold-bearing bedrock exposures





~2.7 Ga Greenstone belt gold mineralization

100 Ma Uplift and erosion.  
Fluvial transport of gold grains and deposition on Cretaceous Paleoshoreline.

Paleoplacer Deposit Forms.  
Longshore transport. Gold grains rounded, form donut-rims, lose their silver.

15 Ka Rainy Lobe advances from the northeast. Erodes paleoplacer deposit and incorporates donut grains into till. Also erodes gold-bearing bedrock exposures



~2.7 Ga Greenstone belt gold mineralization

100 Ma Uplift and erosion.  
Fluvial transport of gold grains and deposition on Cretaceous Paleoshoreline.

Paleoplacer Deposit Forms.  
Longshore transport. Gold grains rounded, form donut-rims, lose their silver.

15 Ka Rainy Lobe advances from the northeast. Erodes paleoplacer deposit and incorporates donut grains into till. Also erodes gold-bearing bedrock exposures





~2.7 Ga Greenstone belt gold mineralization

100 Ma Uplift and erosion.  
Fluvial transport of gold grains and deposition on Cretaceous Paleoshoreline.

Paleoplacer Deposit Forms.  
Longshore transport. Gold grains rounded, form donut-rims, lose their silver.

15 Ka Rainy Lobe advances from the northeast. Erodes paleoplacer deposit and incorporates donut grains into till. Also erodes gold-bearing bedrock exposures



~2.7 Ga Greenstone belt gold mineralization

100 Ma Uplift and erosion.  
Fluvial transport of gold grains and deposition on Cretaceous Paleoshoreline.

Paleoplacer Deposit Forms.  
Longshore transport. Gold grains rounded, form donut-rims, lose their silver.

15 Ka Rainy Lobe advances from the northeast. Erodes paleoplacer deposit and incorporates donut grains into till. Also erodes gold-bearing bedrock exposures



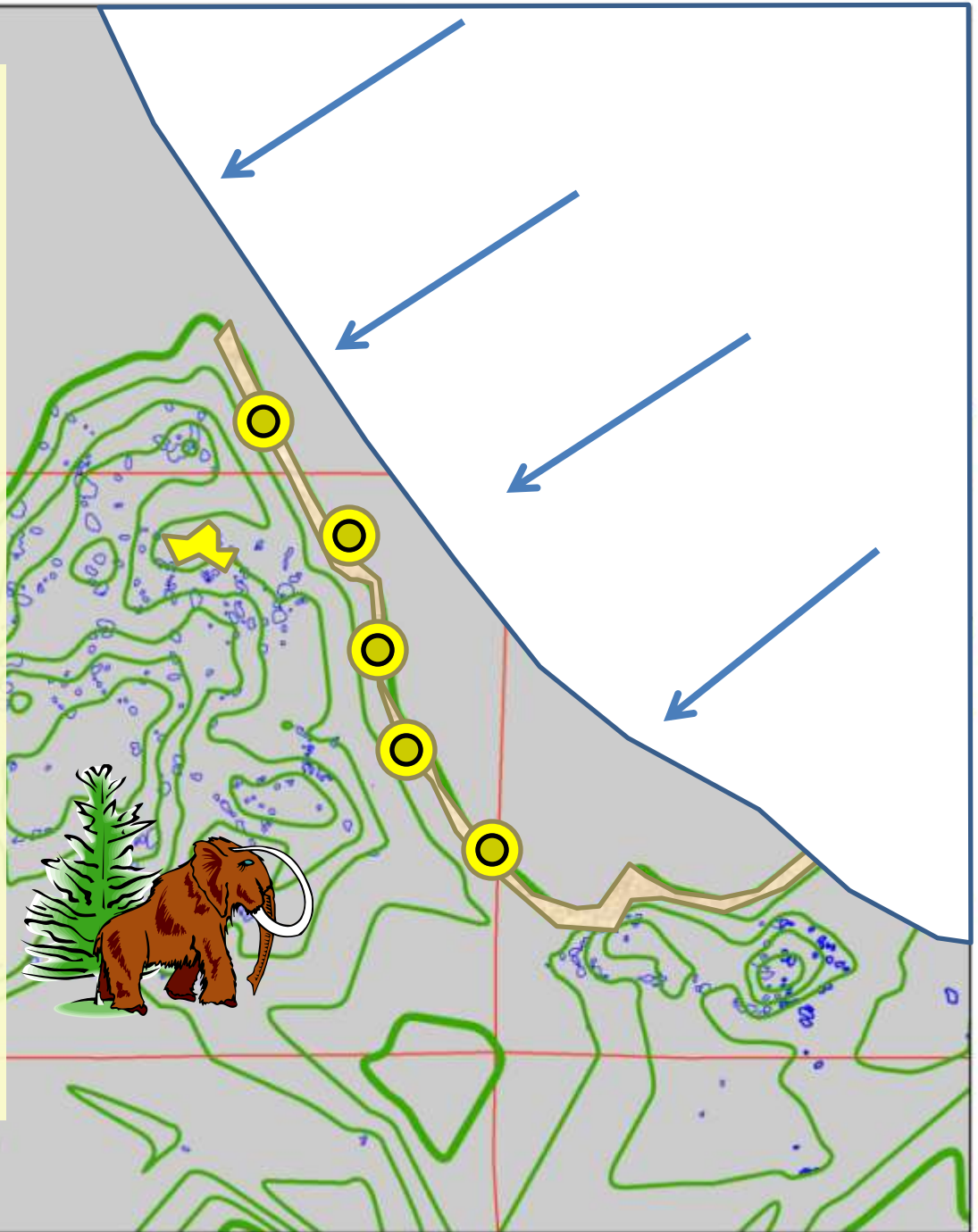


~2.7 Ga Greenstone belt gold mineralization

100 Ma Uplift and erosion.  
Fluvial transport of gold grains and deposition on Cretaceous Paleoshoreline.

Paleoplacer Deposit Forms.  
Longshore transport. Gold grains rounded, form donut-rims, lose their silver.

15 Ka Rainy Lobe advances from the northeast. Erodes paleoplacer deposit and incorporates donut grains into till. Also erodes gold-bearing bedrock exposures

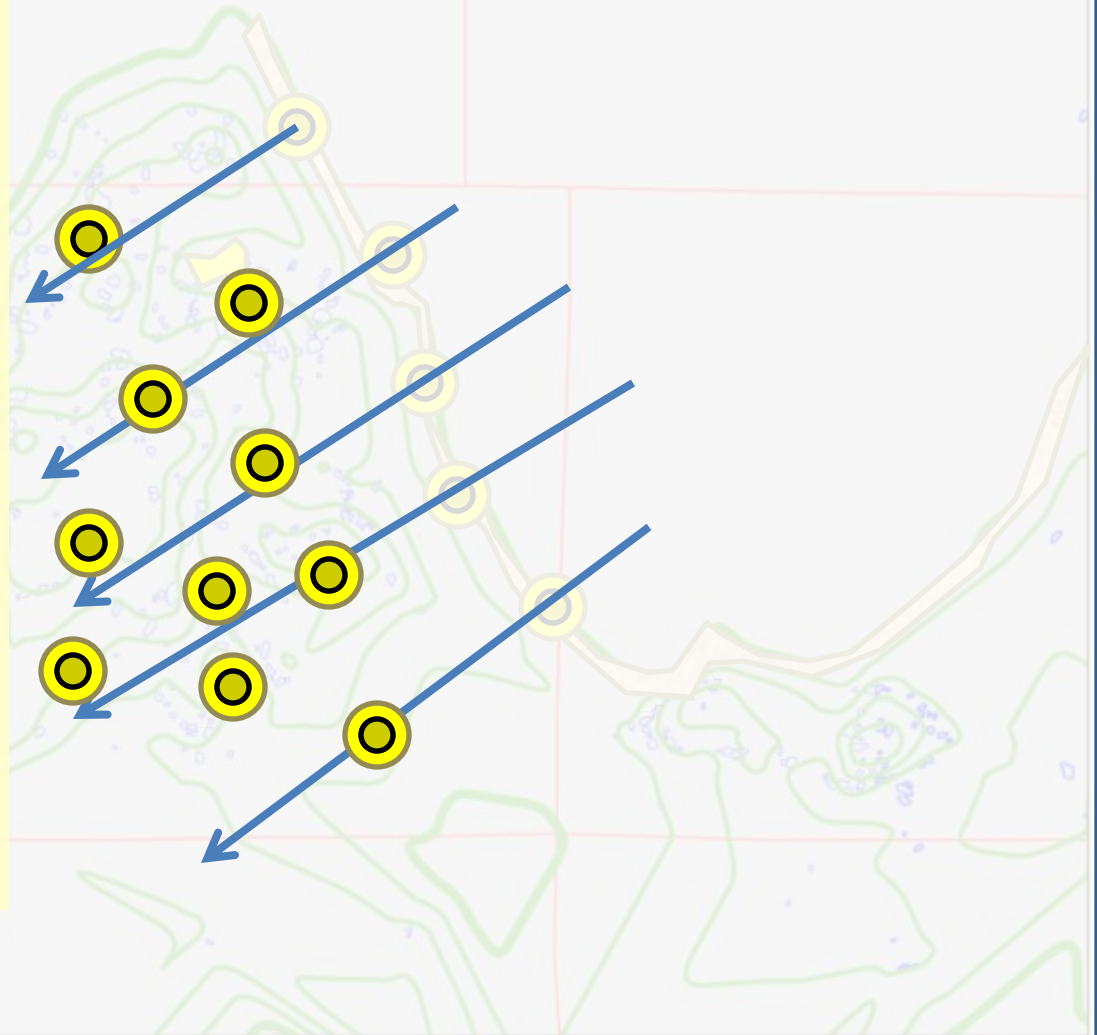


~2.7 Ga Greenstone belt gold mineralization

100 Ma Uplift and erosion.  
Fluvial transport of gold grains and deposition on Cretaceous Paleoshoreline.

Paleoplacer Deposit Forms.  
Longshore transport. Gold grains rounded, form donut-rims, lose their silver.

15 Ka Rainy Lobe advances from the northeast. Erodes paleoplacer deposit and incorporates donut grains into till. Also erodes gold-bearing bedrock exposures



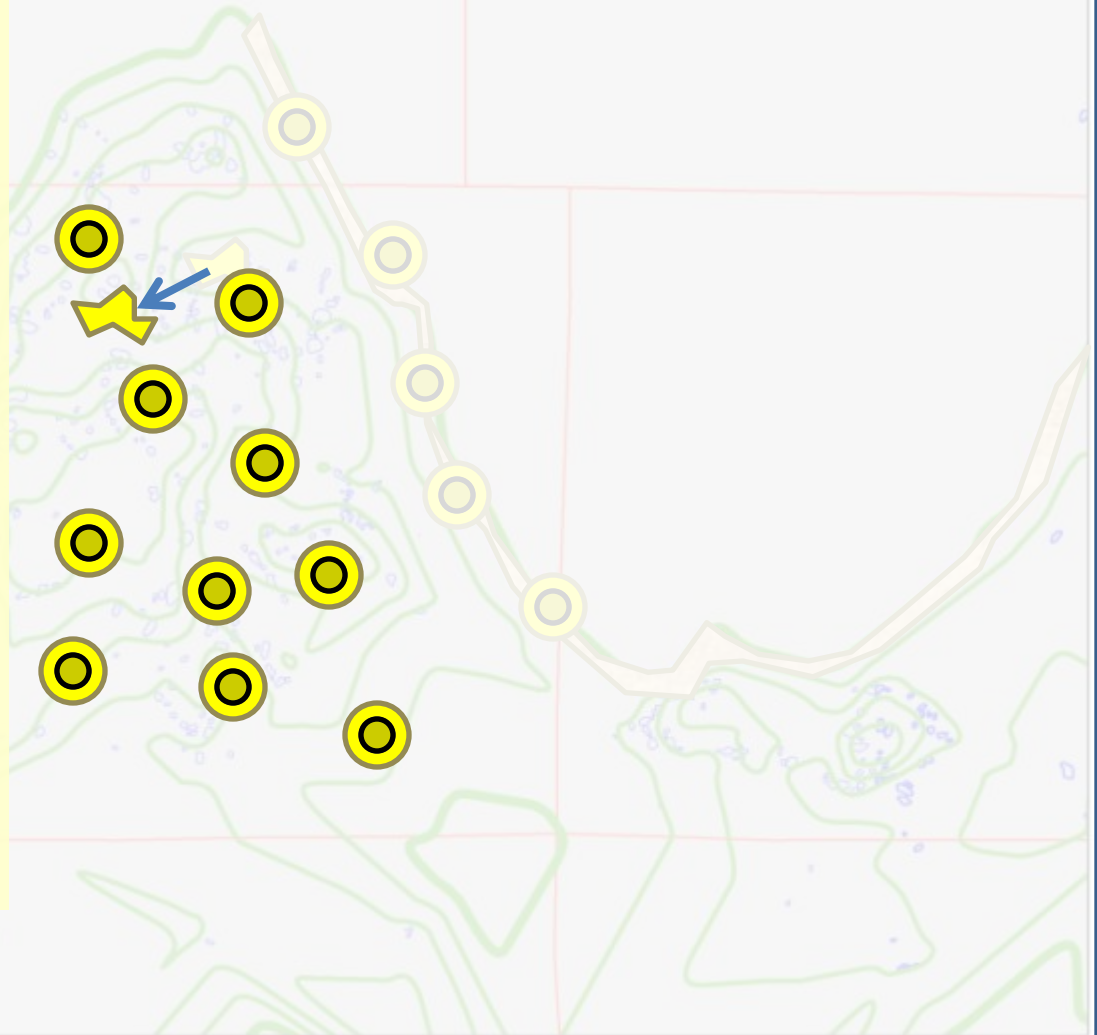


~2.7 Ga Greenstone belt gold mineralization

100 Ma Uplift and erosion.  
Fluvial transport of gold grains and deposition on Cretaceous Paleoshoreline.

Paleoplacer Deposit Forms.  
Longshore transport. Gold grains rounded, form donut-rims, lose their silver.

15 Ka Rainy Lobe advances from the northeast. Erodes paleoplacer deposit and incorporates donut grains into till. Also erodes gold-bearing bedrock exposures

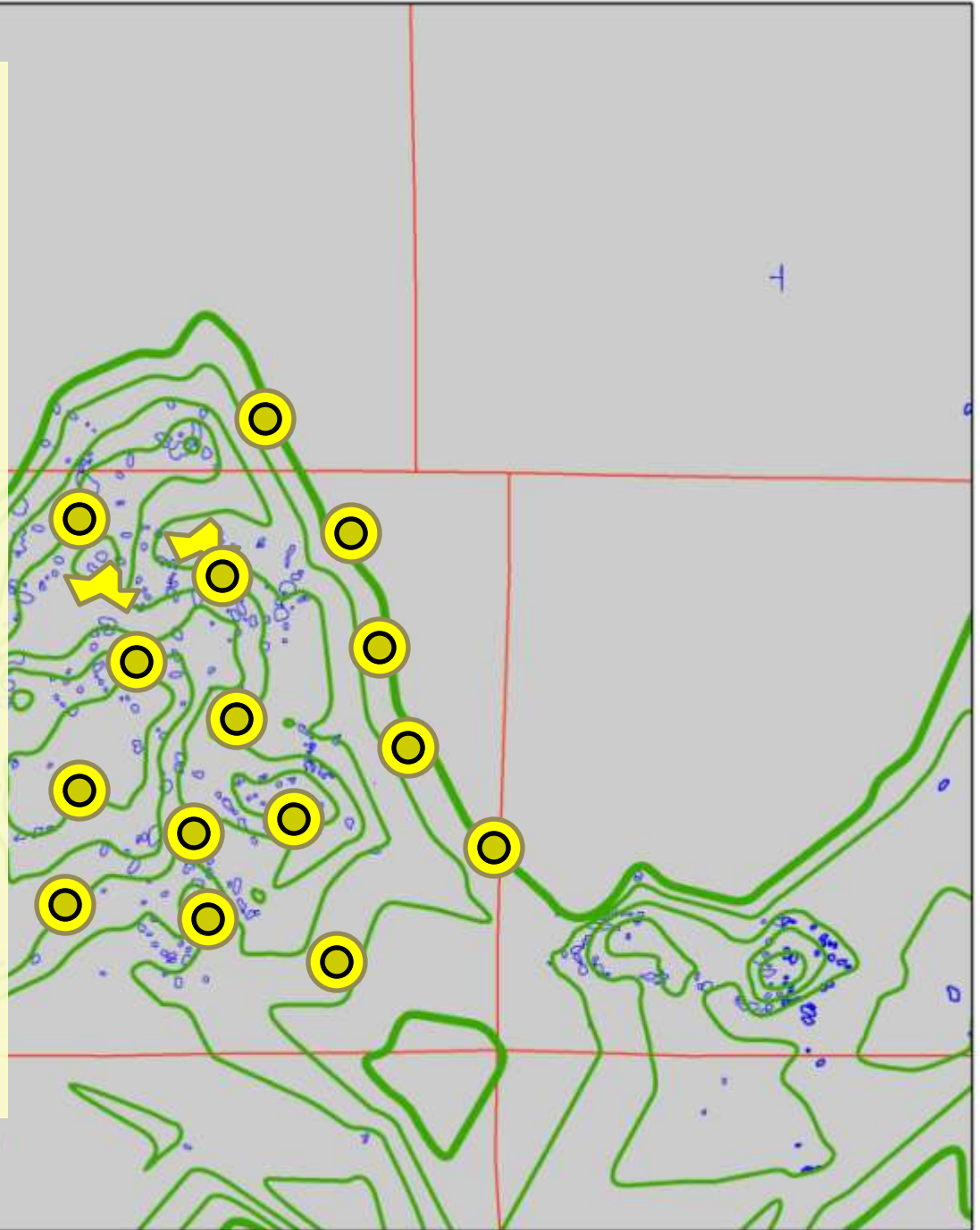


~2.7 Ga Greenstone belt gold mineralization

100 Ma Uplift and erosion.  
Fluvial transport of gold grains and deposition on Cretaceous Paleoshoreline.

Paleoplacer Deposit Forms.  
Longshore transport. Gold grains rounded, form donut-rims, lose their silver.

15 Ka Rainy Lobe advances from the northeast. Erodes paleoplacer deposit and incorporates donut grains into till. Also erodes gold-bearing bedrock exposures





An alternative hypothesis to explain the formation of toroidal gold grain morphology involves the formation of aeolian placer deposits, potentially during an interglacial period.







# State Metallic Mineral Lease Sale

# April 28, 2011



The screenshot shows the Minnesota Department of Natural Resources website. The header includes the state logo and the department name. A navigation bar lists various categories: Recreation, Destinations, Nature, Education / safety, and Licenses / permits / regs. The main content area is titled 'Metallic Minerals Lease Sale' and includes a 'Notice of Sale of State Metallic Minerals Leases'. The notice text states that a sale of leases to explore for, mine and remove metallic minerals in trust fund lands, lands and minerals forfeited for non-payment of taxes, lands and minerals otherwise acquired, and other state-owned land under the jurisdiction of the Commissioner of Natural Resources, and located in portions of Itasca, Koochiching, Lake and Saint Louis Counties, is scheduled to be held on Thursday, April 28, 2011, at 9:00 a.m. The sale will take place at the Central Offices of the Division of Lands and Minerals, 4th Floor, East-West Conference Room DNR Building, 500 Lafayette Road, Saint Paul, Minnesota. No land or water areas within the Boundary Water Canoe Area Wilderness or Voyageurs National Park are included in this or any State mineral lease sale. The Commissioner will receive sealed bids and applications for leases covering minerals in state lands, in accordance with Minnesota Rules, parts 6125.0100 through 6125.0700 and the metallic mineral rules issued under the authority of Minnesota Statutes, Chapter 93. Each bid must be submitted on a form obtained from the Commissioner. Each bid form must be accompanied by a certified check, cashier's check, or bank money order, payable to the Department of Natural Resources in the sum of the following amounts: a) an application fee of \$100.00 for each mining unit bid upon; and b) rental for one full calendar year for each mining unit bid upon. All bids must be received by the Commissioner at the office of the Division of Lands and Minerals, Fourth Floor, DNR Building, 500 Lafayette Road, Saint Paul, Minnesota 55155-4045.

**Minnesota Department of Natural Resources**

Recreation | Destinations | Nature | Education / safety | Licenses / permits / regs.

Home > Lands & Minerals >

**Division of Lands & Minerals**

- [Main page](#)
- [Aggregate maps](#)
- [Contacts](#)
- [FAQs](#)
- [For kids - Digging into MN Minerals](#)
- [Geology recreation](#)
- [Land sale](#)
- [Metallic minerals - current notice](#)
- [Mineral exploration](#)
- [Monthly data releases](#)
- [Preference rights leases](#)
- [Public access to minerals data: 100 years of data](#)
- [Publications](#)

## Metallic Minerals Lease Sale

### Notice of Sale of State Metallic Minerals Leases

Notice is hereby given that a sale of leases to explore for, mine and remove metallic minerals in trust fund lands, lands and minerals forfeited for non-payment of taxes, lands and minerals otherwise acquired, and other state-owned land under the jurisdiction of the Commissioner of Natural Resources, and located in portions of Itasca, Koochiching, Lake and Saint Louis Counties, is scheduled to be held on Thursday, April 28, 2011, at 9:00 a.m. The sale will take place at the Central Offices of the Division of Lands and Minerals, 4th Floor, East-West Conference Room DNR Building, 500 Lafayette Road, Saint Paul, Minnesota. No land or water areas within the Boundary Water Canoe Area Wilderness or Voyageurs National Park are included in this or any State mineral lease sale.

The Commissioner will receive sealed bids and applications for leases covering minerals in state lands, in accordance with Minnesota Rules, parts 6125.0100 through 6125.0700 and the metallic mineral rules issued under the authority of Minnesota Statutes, Chapter 93. Each bid must be submitted on a form obtained from the Commissioner. Each bid form must be accompanied by a certified check, cashier's check, or bank money order, payable to the Department of Natural Resources in the sum of the following amounts: a) an application fee of \$100.00 for each mining unit bid upon; and b) rental for one full calendar year for each mining unit bid upon. All bids must be received by the Commissioner at the office of the Division of Lands and Minerals, Fourth Floor, DNR Building, 500 Lafayette Road, Saint Paul, Minnesota 55155-4045.

# For More Information:

## Gold Mineralization and Geology of Northern Minnesota

Don Elsenheimer, Minnesota DNR  
[donald.elsenheimer@state.mn.us](mailto:donald.elsenheimer@state.mn.us)  
(651) 259-5433

Barry Frey, Minnesota DNR  
[barry.frey@state.mn.us](mailto:barry.frey@state.mn.us)  
(218) 231-8484



## State of Minnesota Metallic Mineral Leases

Aaron Vande Linde, Minnesota DNR  
[aaron.vande-linde@state.mn.us](mailto:aaron.vande-linde@state.mn.us)  
(651) 259-5955

## Reference for ODM photographs and figures used in this presentation:

AVERILL, S.A. 2001. The application of heavy indicator mineralogy in mineral exploration with emphasis on base metal indicators in glaciated metamorphic and plutonic terrains. In: McCLENAGHAN, M.B. BOBROWSKY, P.T. HALL, G.E.M. & COOK, S.J. (eds) *Drift Exploration in Glaciated Terrains*. Geological Society, London, Special Publications, **185**, 69-81.