

# DGGS Earth MRI Geologic Mapping and Geophysics Program Update

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Alaska Division of Geological & Geophysical Surveys



# The Continuously Growing Team

## Geophysical Survey

### contractors:

EON Geosciences

SkyTEM

MPX Geophysics Ltd.

Geotech Ltd.

Industry cooperation: Northern Star, Tectonic Metals, Resolution Minerals, Millrock Resources, SAM Alaska, AK USA Critical Metals Inc., Western Alaska Copper & Gold

Land access to parts of the study area:

Doyon Ltd., Bureau of Land Management

## 2023-2024 Geologic Mapping

~~Team~~ Alicia Wypych

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Zoom Szumigala

Jenna Beigel

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David Harvey

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Lily Norwood

Evan Twelker

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Fairbanks, University of Texas Austin, Arizona

LaserChron, Lamont-Doherty Earth

Observatory

USGS Earth MRI collaborators: Jamey Jones, Doug Kreiner, Ben Drenth, Jacob M. Mischek, George Case, Paul Bedrosian,

Jamie Azain

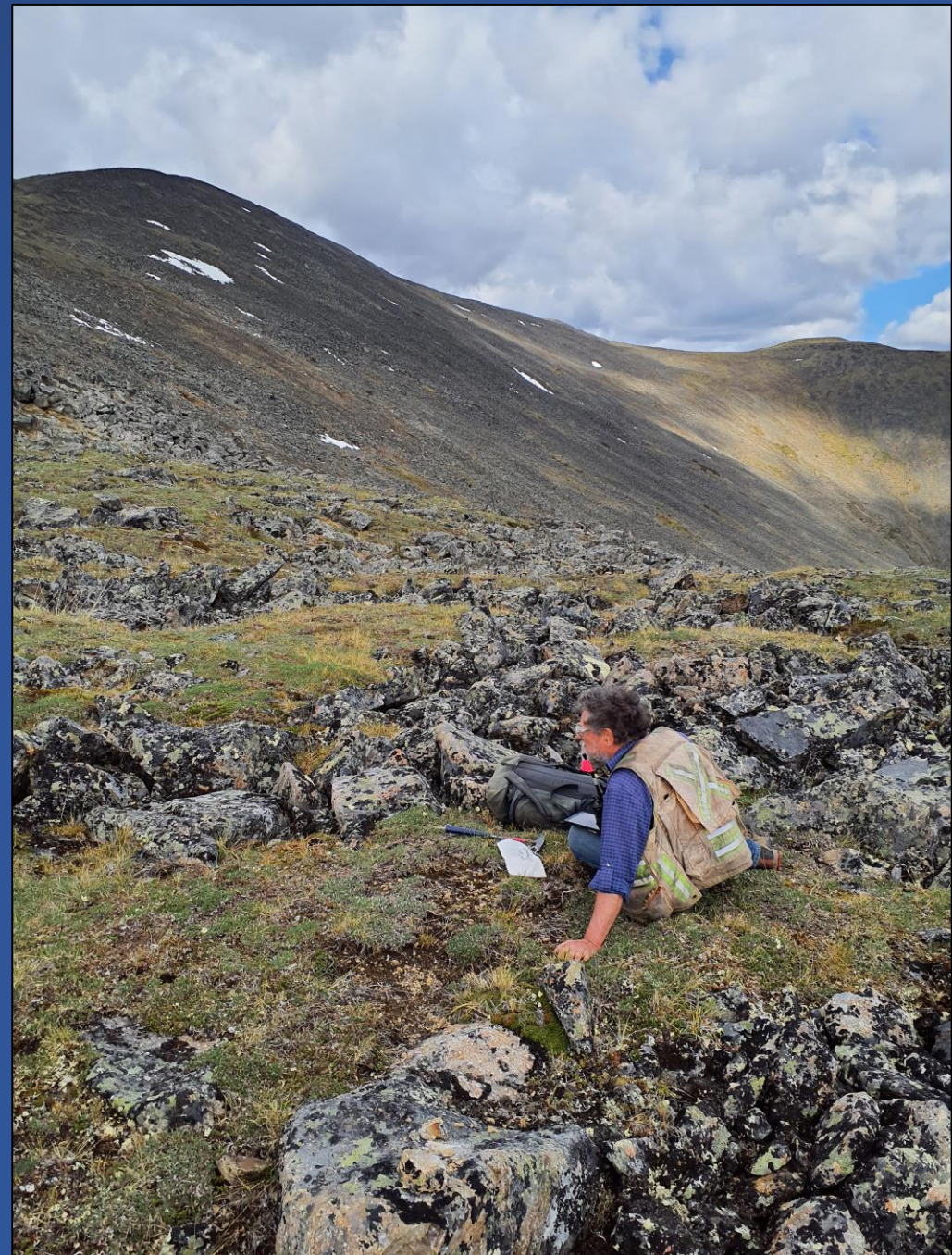
Funding for geophysical surveys and geologic mapping provided by U.S. Geological Survey Earth Mapping Resources Initiative (Earth MRI) cooperative agreements G19AC00263, G20AC00160, G21AC10326, G22AC00475, G23AC00408; G19AC00262, G20AC00156, G21AC00336, G22AC00288, G23AC00372, G24AC00323 ; plus additional State of Alaska funds.

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Geological Survey. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Geological Survey.



# Talk Outline

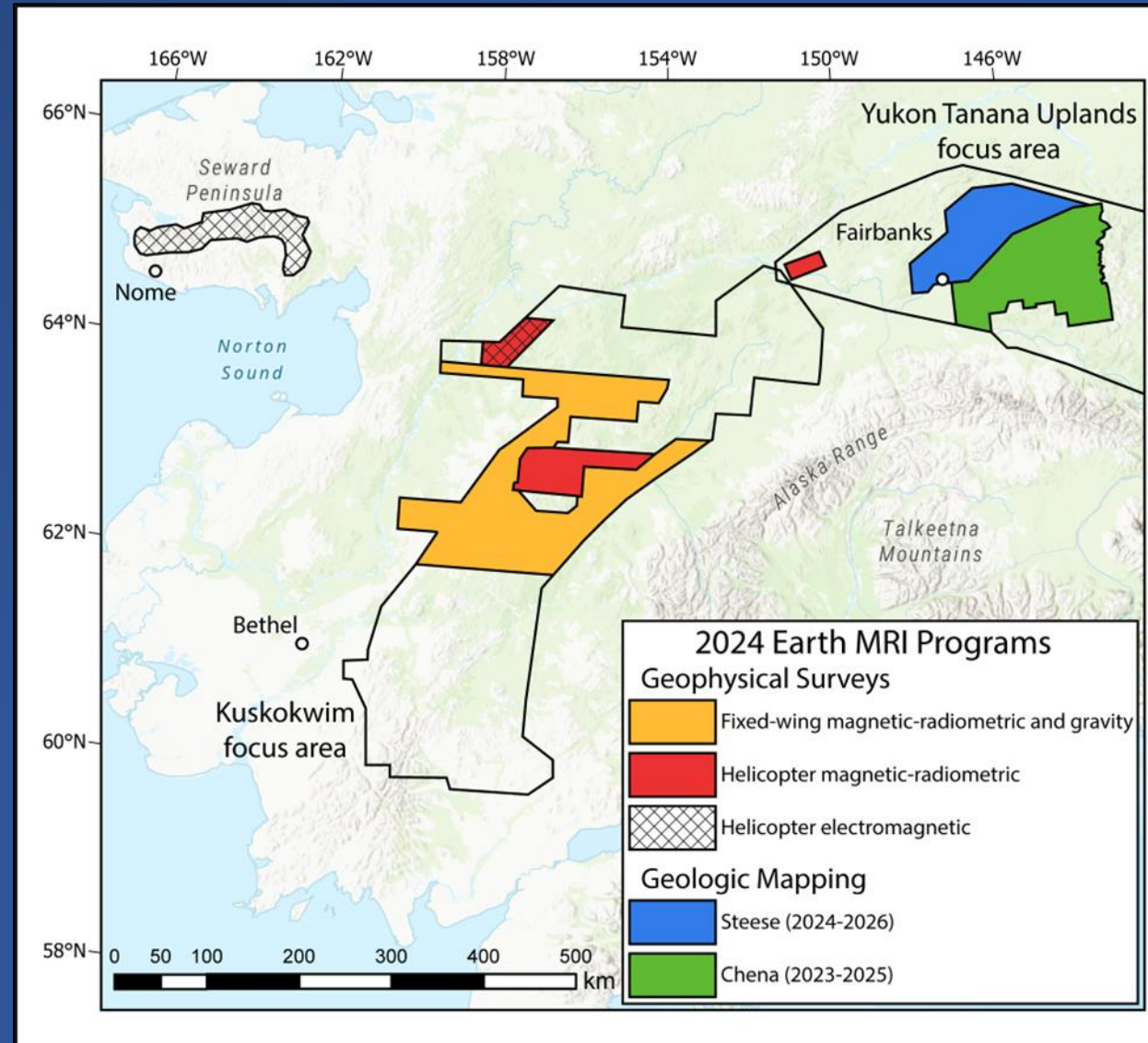
- Earth MRI introduction
- Building the framework
- Geophysics update
- Geologic mapping update
- Highlights
  - New data
  - New methods
  - New mapping
- The Big Picture





# What is Earth MRI?

- “Earth Mapping Resources Initiative”
- USGS geologic framework mapping program focused on critical minerals
- Partnership with state geological surveys
- Three main components:
  - Geophysical surveys
  - Geologic mapping
  - Geochemical mapping
- Mineral systems approach:
  - Broad footprints
  - Many critical minerals are produced as co-products in conventional mineral deposits

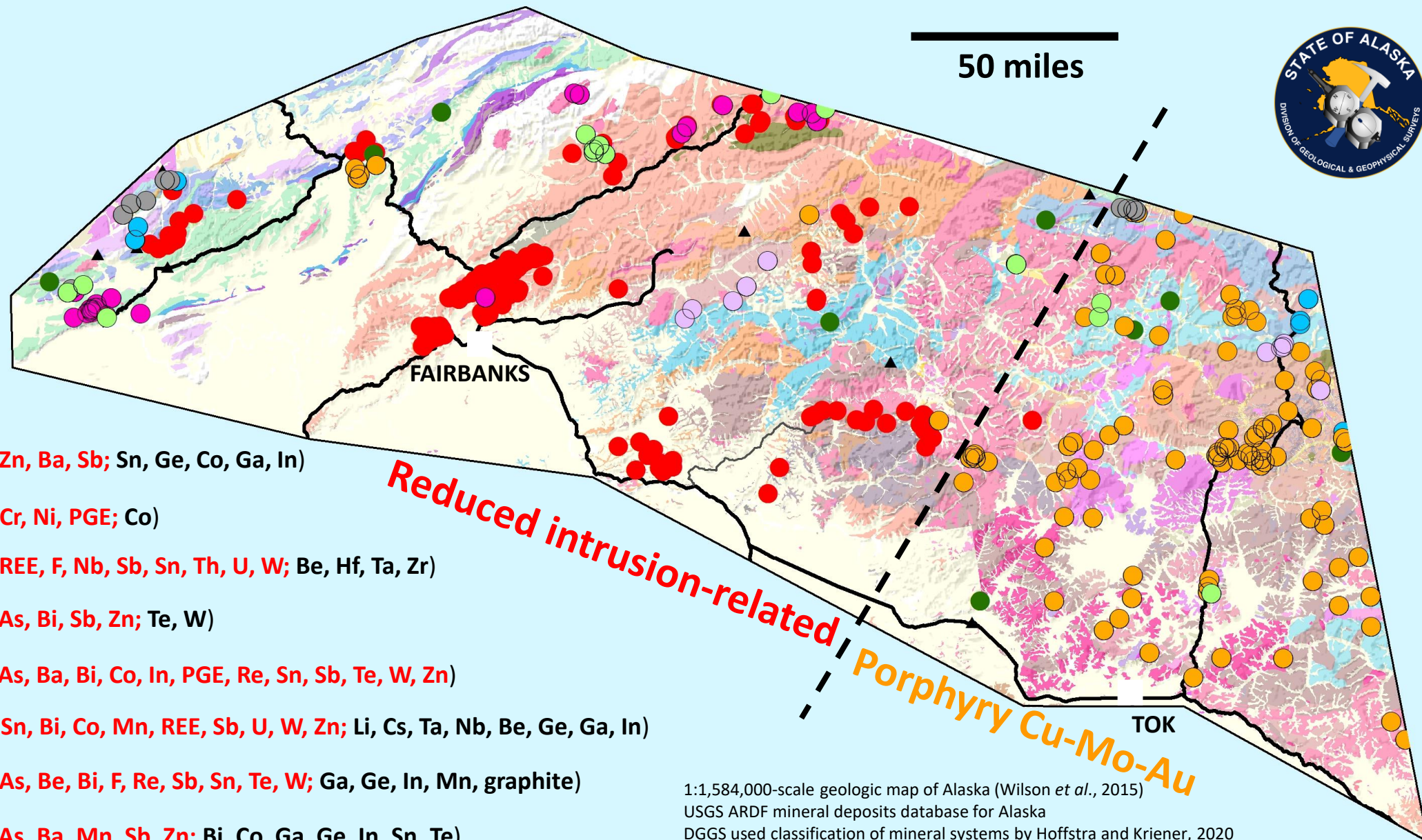




# Known mineral occurrences in YTU



50 miles



## Known Mineral Occurrences

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### Color Coded By Mineral System

- ▲ Unknown mineral system
- Basin brine path
- Mafic magmatic
- Magmatic REE
- Orogenic
- Porphyry Cu-Mo-Au
- Porphyry Sn (granite-related)
- Reduced intrusion-related
- Volcanogenic seafloor

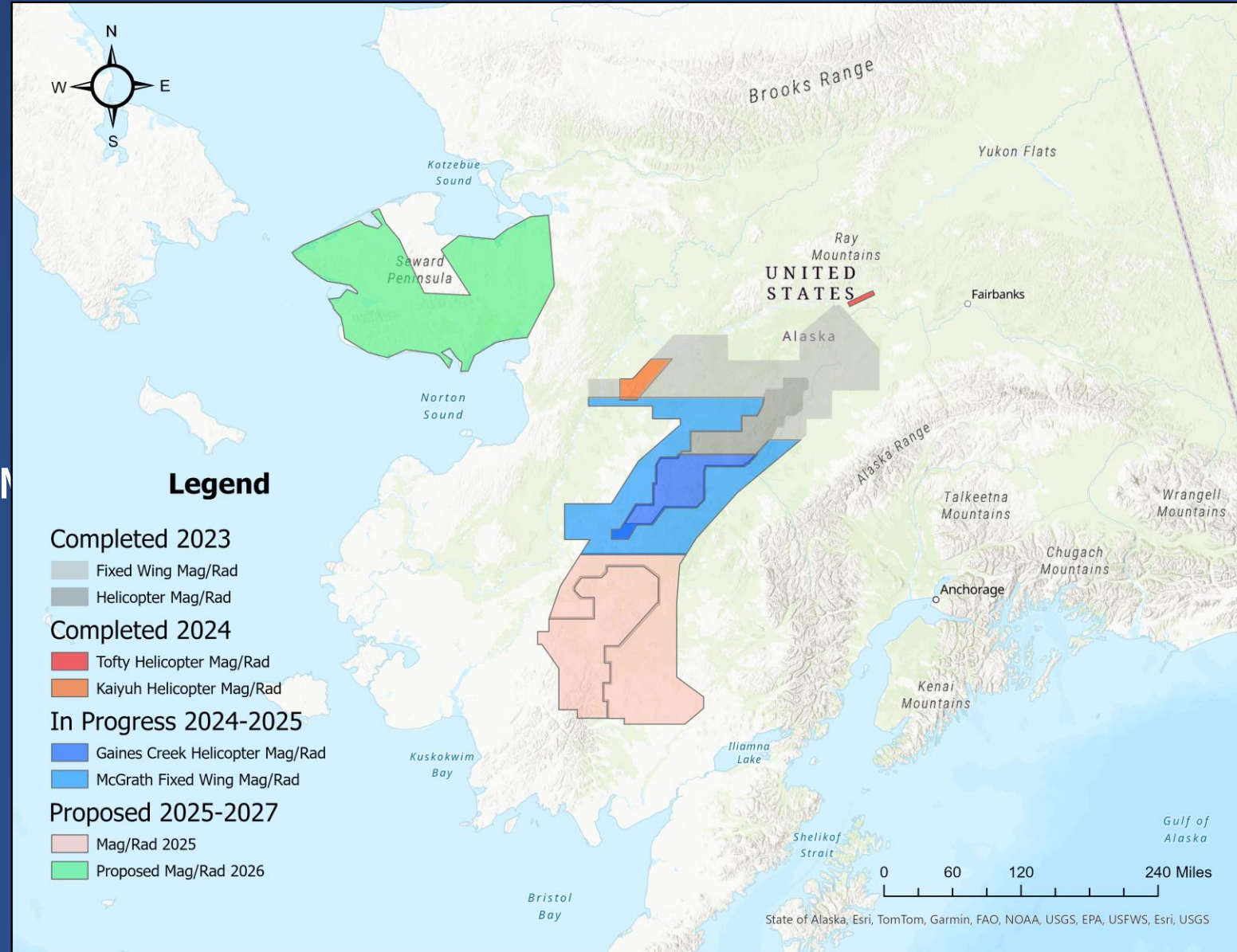
- (Zn, Ba, Sb; Sn, Ge, Co, Ga, In)
- (Cr, Ni, PGE; Co)
- (REE, F, Nb, Sb, Sn, Th, U, W; Be, Hf, Ta, Zr)
- (As, Bi, Sb, Zn; Te, W)
- (As, Ba, Bi, Co, In, PGE, Re, Sn, Sb, Te, W, Zn)
- (Sn, Bi, Co, Mn, REE, Sb, U, W, Zn; Li, Cs, Ta, Nb, Be, Ge, Ga, In)
- (As, Be, Bi, F, Re, Sb, Sn, Te, W; Ga, Ge, In, Mn, graphite)
- (As, Ba, Mn, Sb, Zn; Bi, Co, Ga, Ge, In, Sn, Te)

1:1,584,000-scale geologic map of Alaska (Wilson *et al.*, 2015)  
 USGS ARDF mineral deposits database for Alaska  
 DGGs used classification of mineral systems by Hoffstra and Kriener, 2020



# Airborne magnetic & radiometric surveys

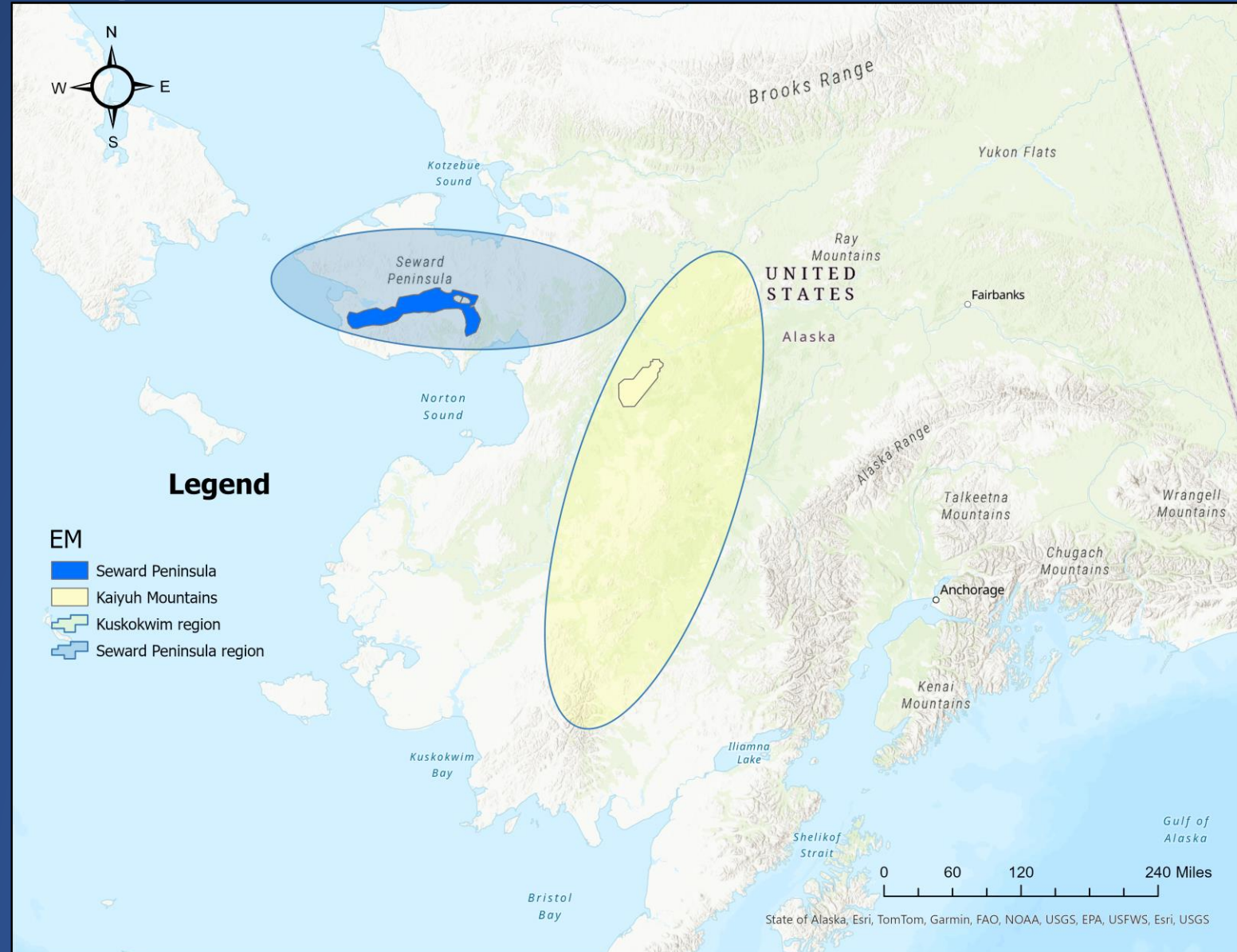
- Primarily Earth MRI funded
- Generally 400m line spacing
- Kaiyuh
  - industry partner - Doyon
- Tofty
  - Focused on carbonatite belt
  - DGGs and industry funded - ACM
  - 100 to 200m line spacing





# Airborne electromagnetic surveys

- Seward Peninsula
  - Kigluik, Bendeleben, and Darby Mountains -USGS funded
  - Pilgrim Hot Springs - DGGS funded
- Kaiyuh
  - DGGS and industry funded – WAM
- Future
  - State of Alaska funded district-scale surveys within Earth MRI focus regions subject to funding availability





# Airborne gravity surveys

- Partnership with Lamont-Doherty Earth Observatory
- Small inertial gravimeter
- Cost effective
  - Equipment added to FW mag/rad survey
- State of Alaska funded
- ~5 km resolution
- Data release spring 2025





# Seward Peninsula airborne electromagnetic survey

- USGS funded DGGs-USGS partnership supporting USGS graphite assessment
- Time Domain Electromagnetic data - SkyTEM 306HP System
- 4330 line-km
- ~1 km line spacing
- 4800 square-km
- Completed July 2024
- SkyTEM produced resistivity models available now
- USGS resistivity models available in 1 to 2 years

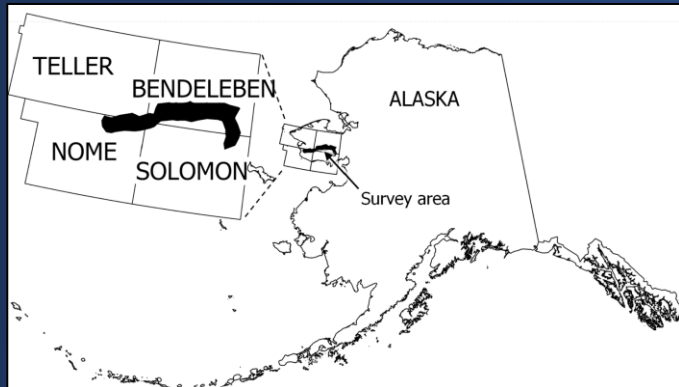
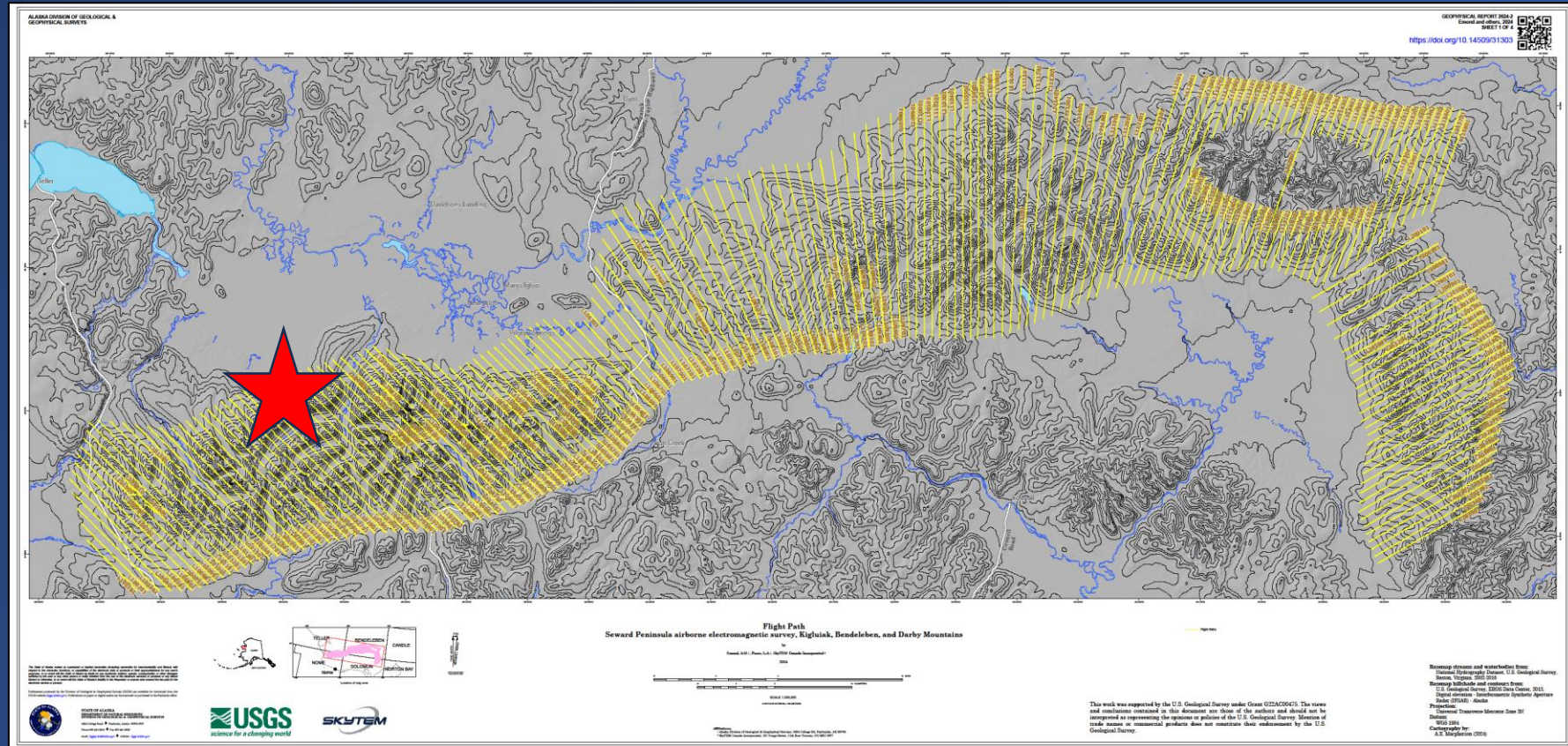


Photo credit: SkyTEM



Emond, A.M., Fusso, L.A., and SkyTEM Canada Incorporated, 2024, Seward Peninsula airborne electromagnetic survey, Kigluik, Bendeleben, and Darby Mountains: Alaska Division of Geological & Geophysical Surveys Geophysical Report 2024-2. <https://doi.org/10.14509/31303>

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# Seward Peninsula airborne electromagnetic survey

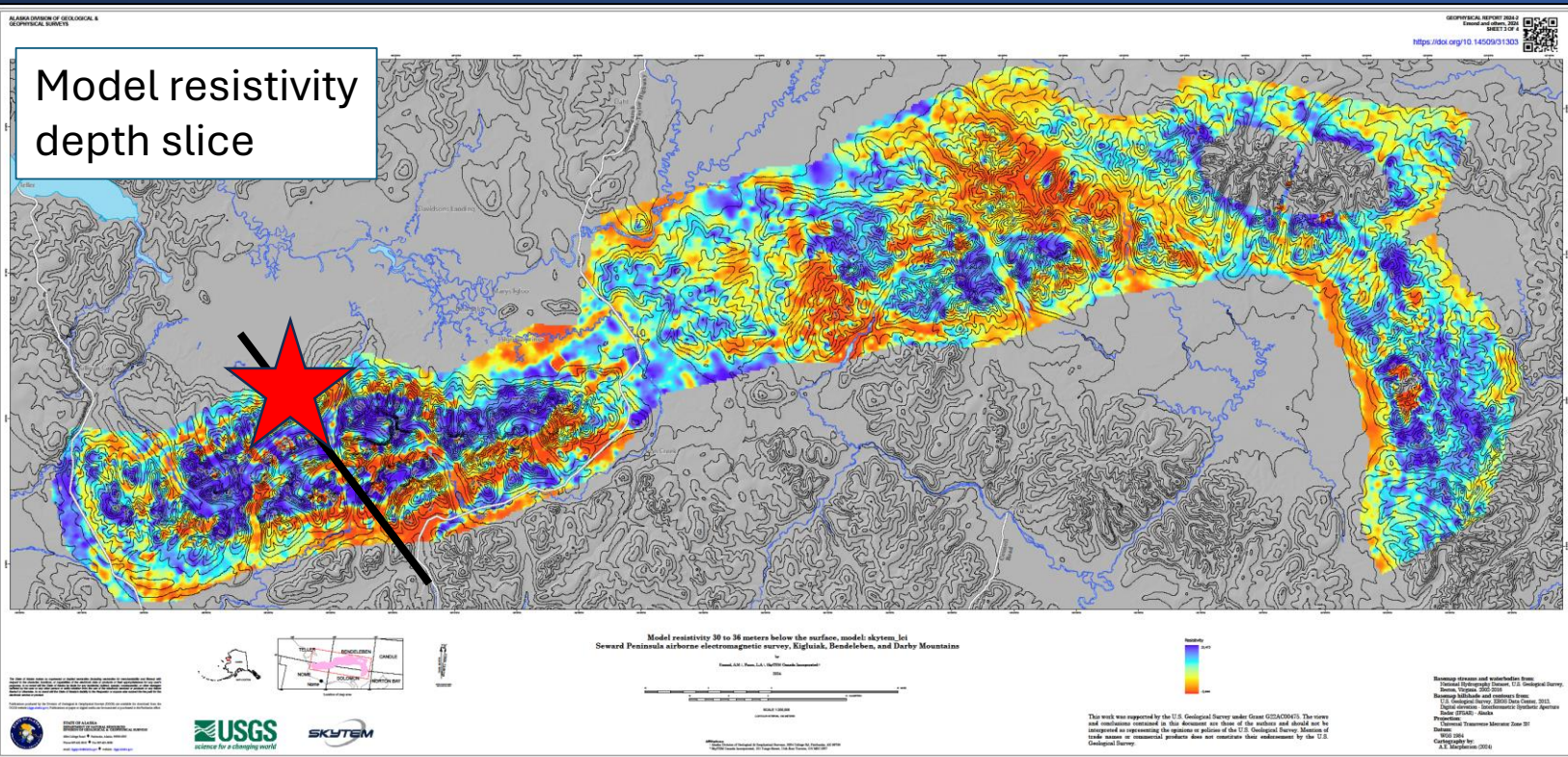
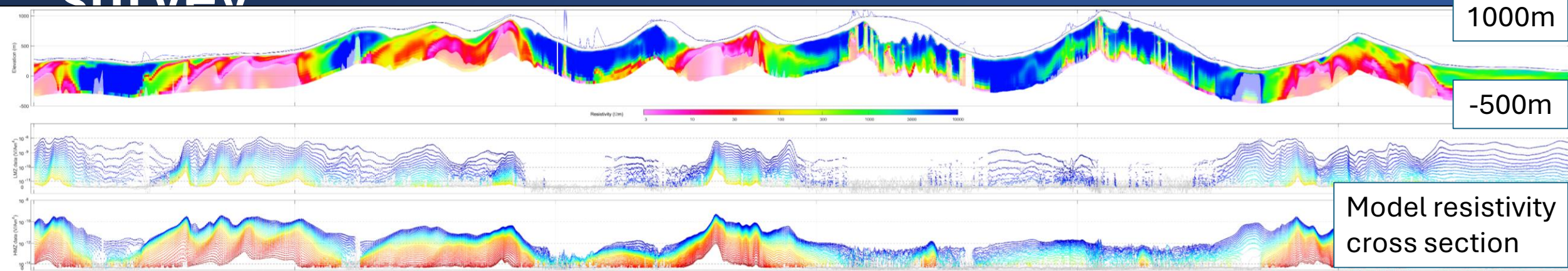


Photo credit: SkyTEM



# Kaiyuh Mountains airborne electromagnetic

## survey

- State of Alaska Funded
- Time Domain Electromagnetic data - SkyTEM 306HP System
- 5800 line-km
- 400m line spacing with industry infill (Doyon and Western Alaska Minerals)
- 2000 square-km
- Completed August 2024
- Planned Release 2025

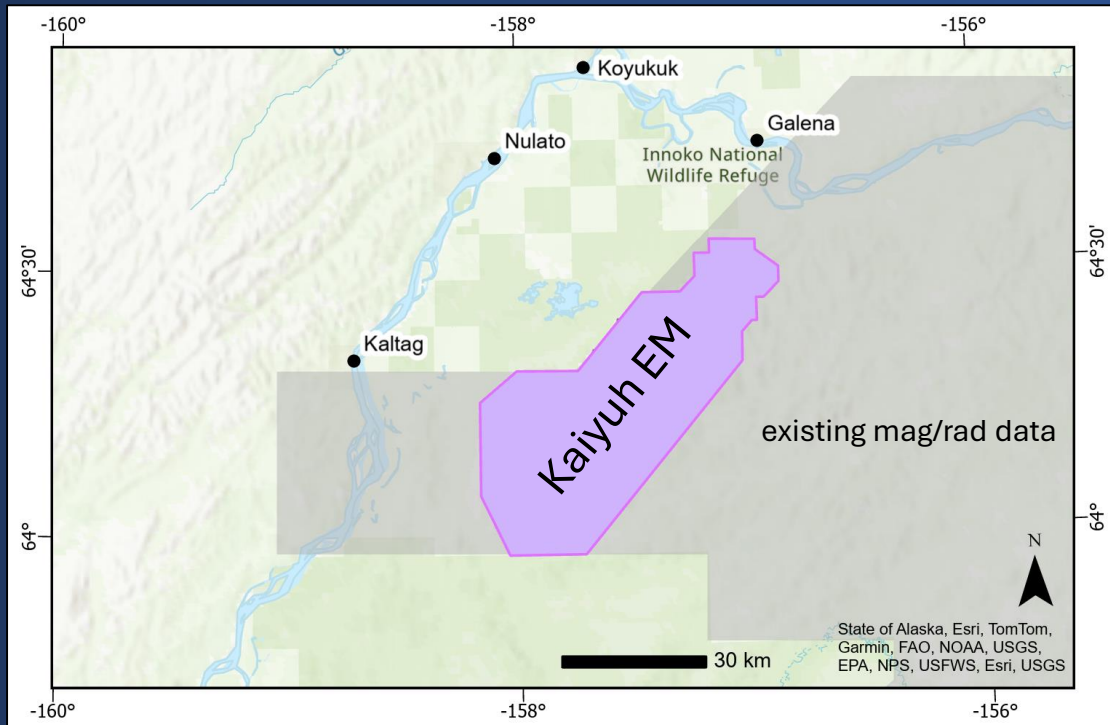
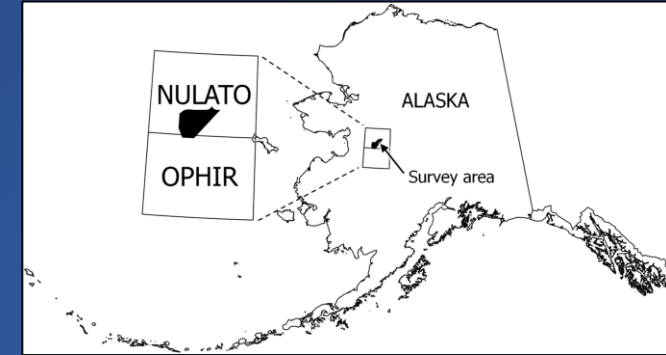
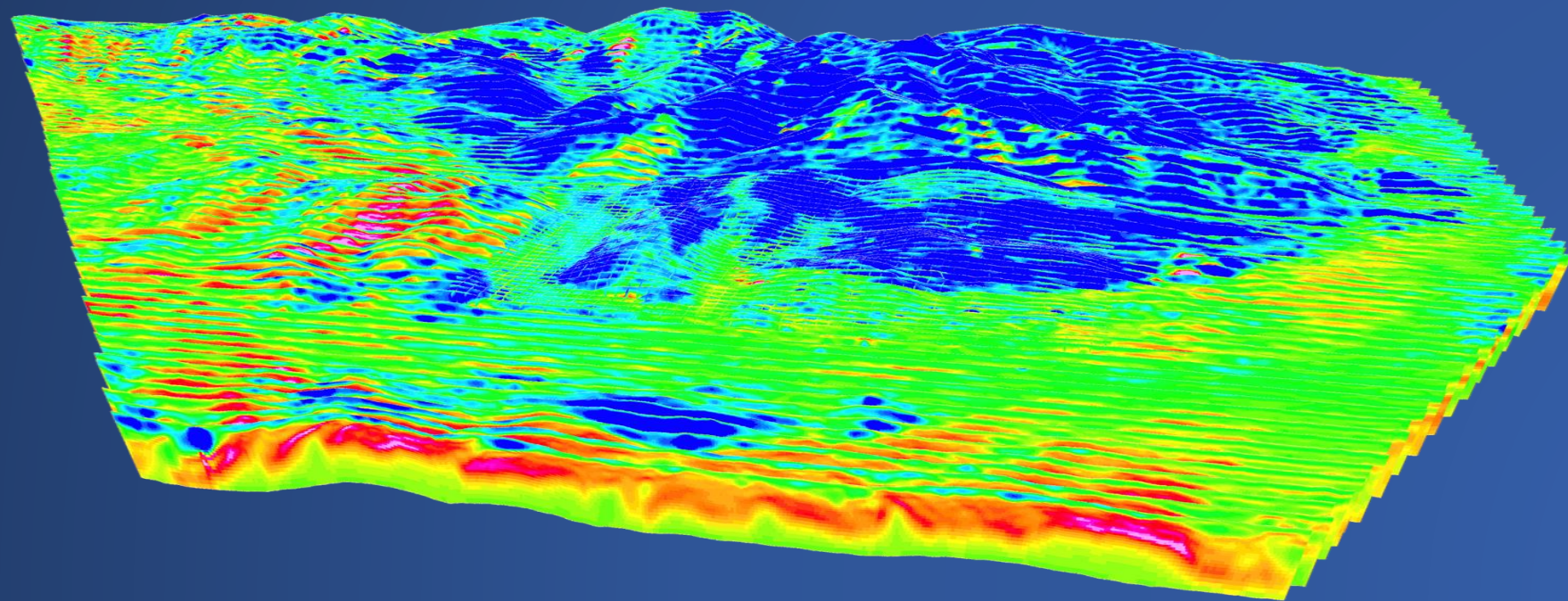
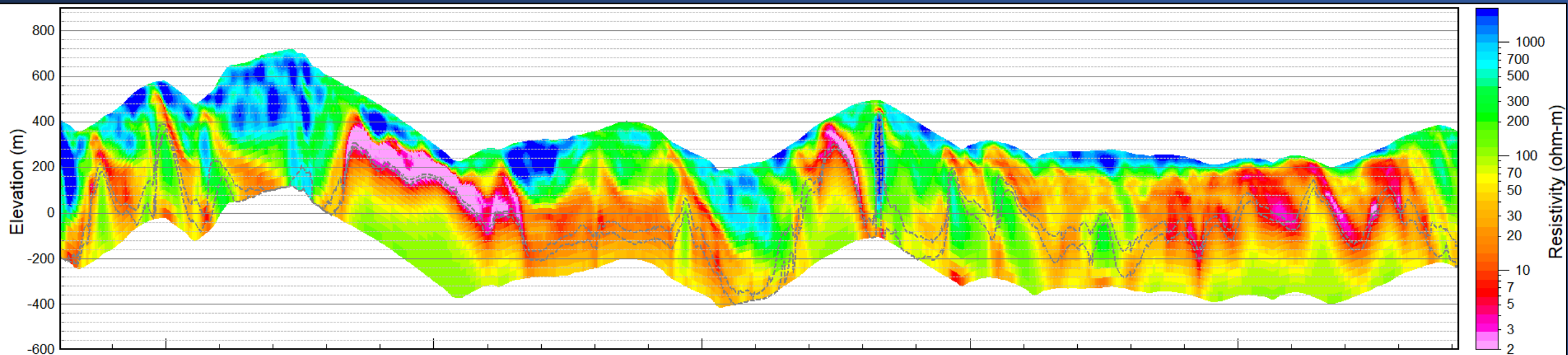


Photo credit: SkyTEM

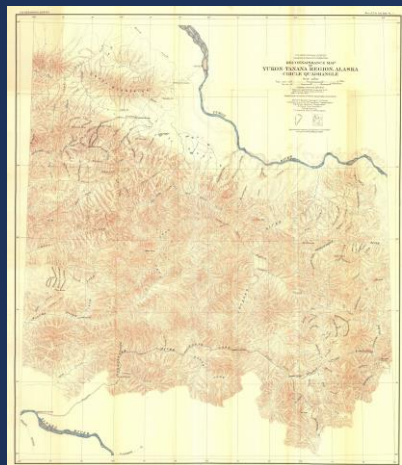


# Example resistivity models

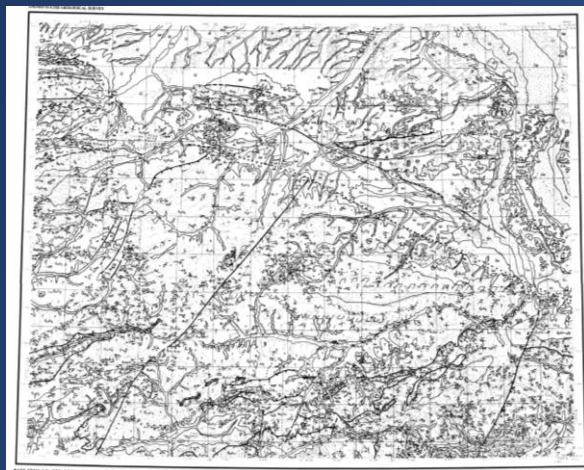




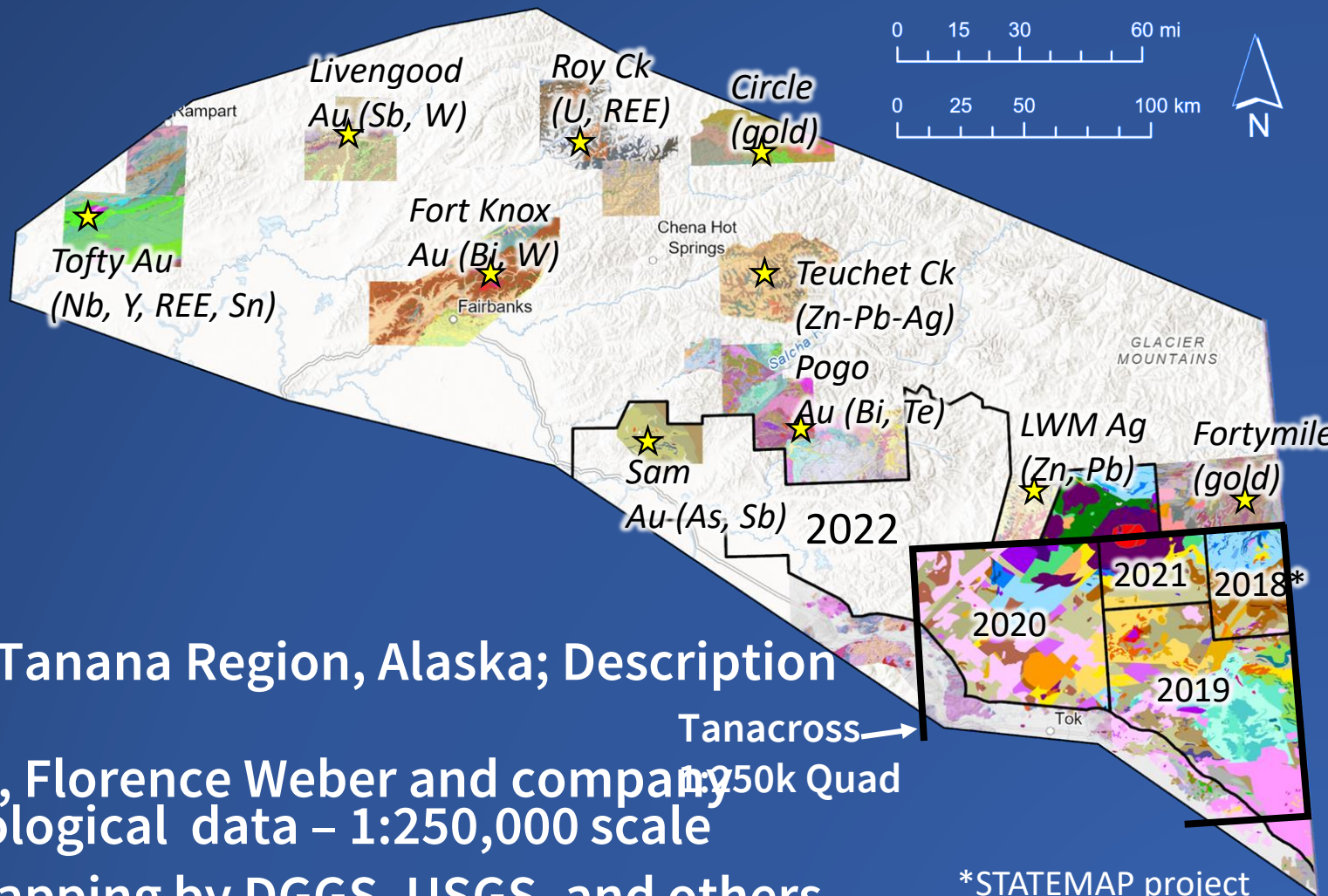
# A Brief History YTU Geologic Mapping



Prindle, 1906



Foster and others, 1976



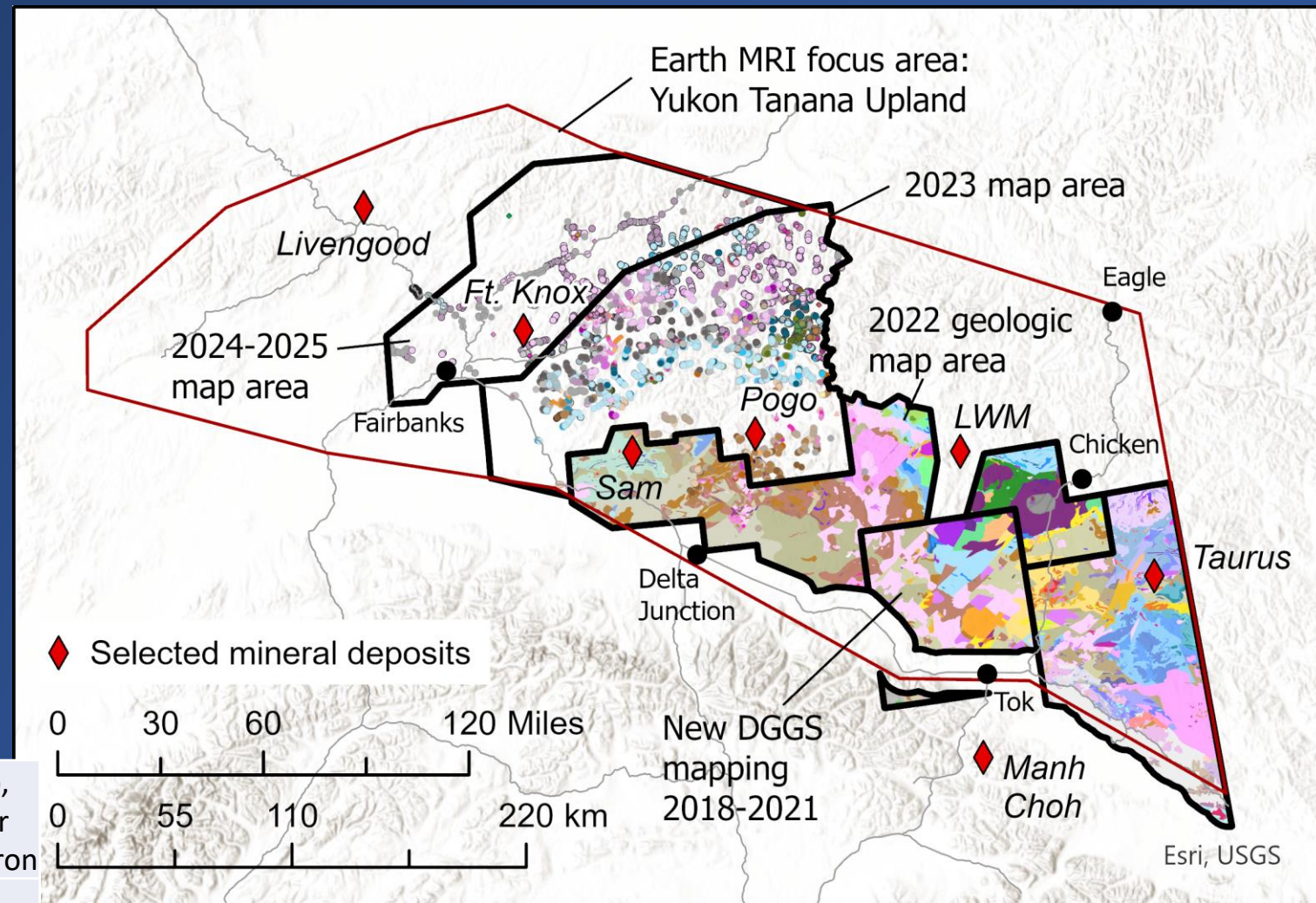
\*STATEMAP project

- 1906 – USGS – L.M Prindle – Yukon Tanana Region, Alaska; Description of the Circle Quadrangle
- 1960s-1970s – USGS – Helen Foster, Florence Weber and company – limited geophysical and geochronological data – 1:250,000 scale
- Past 20-30 years – More detailed mapping by DGGS, USGS, and others
- 2018 – DGGS – STATEMAP project in YTU
- 2019 to Present – DGGS mapping under Earth MRI



# Current Program

- Mix of compilation and new mapping
- 1:100,000 scale
- Resolve existing map conflicts
- Geochemical and geochronologic data to help refine and map magmatic suites and metamorphic terranes
- Structure and deformation in metamorphic rocks



2023, 2024 mapping stations (colored by map unit)

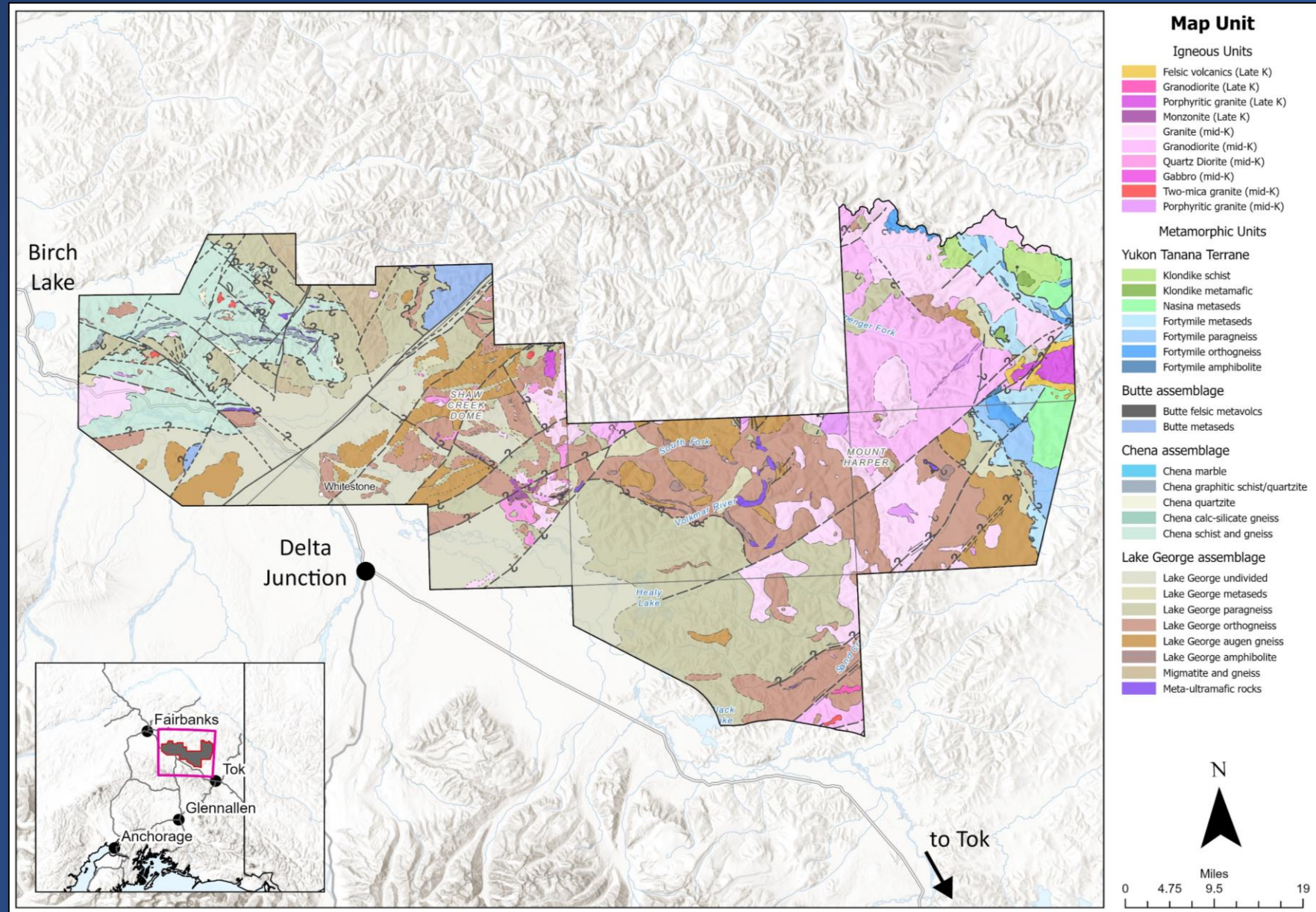
Understand the terrane scale framework to characterize known mineral occurrences

	Square miles	Square km	Person-days in field	Rock Geochem	U-Pb, Ar/Ar Geochron
FFY2019	1,865	4,829	315	407	58
FFY2020	1,717	4,446	320	320	72
FFY2021	899	2,328		146	
FFY2022	3,102	8,033	460	401	66
FFY2023	5,604	14,515	505	428	33
FFY2024	3,475	9,000	380	364	72
<b>Total</b>	<b>16,662</b>	<b>43,151</b>	<b>1,980</b>	<b>2,066</b>	<b>301</b>



# Harper-Richardson Project

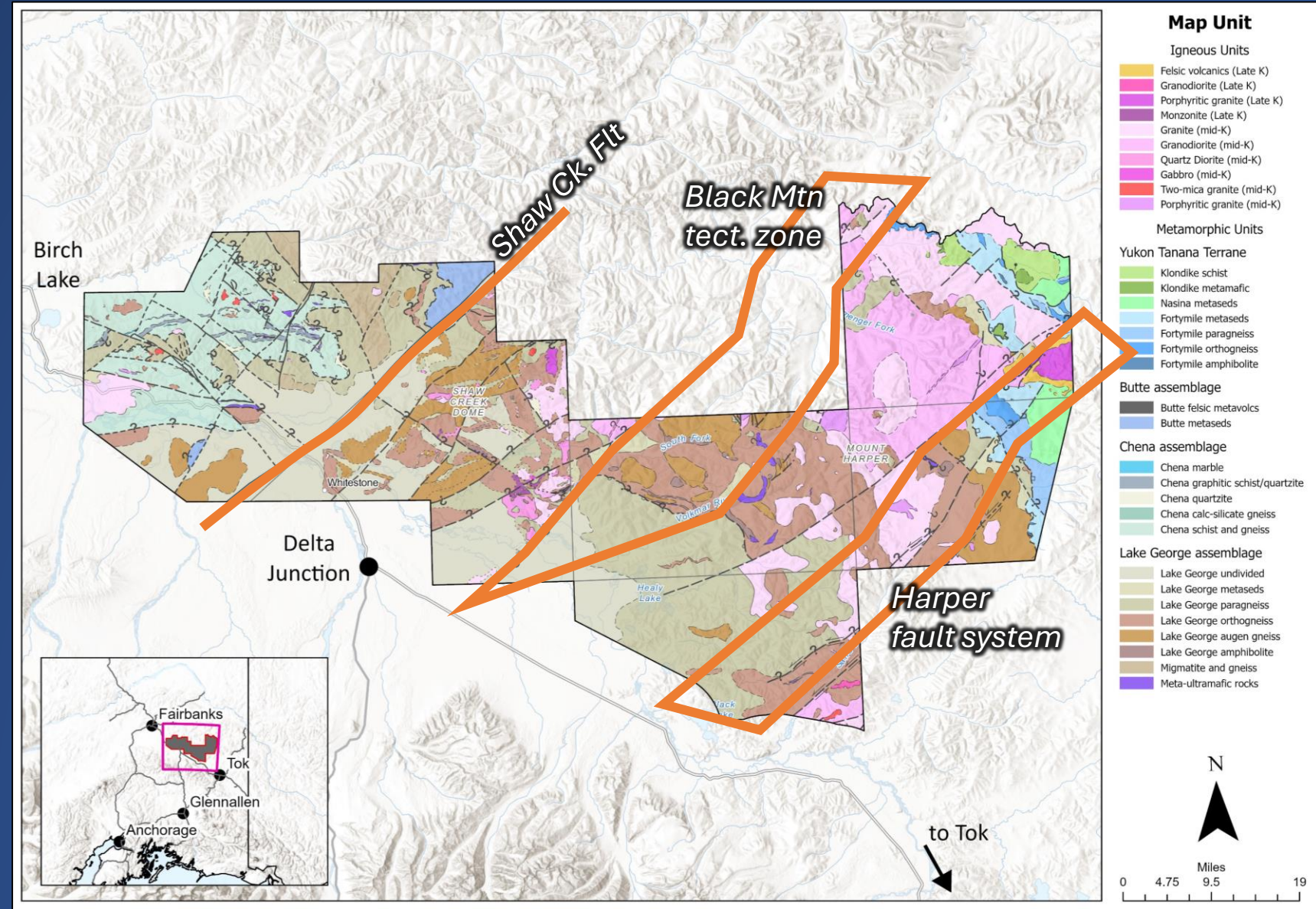
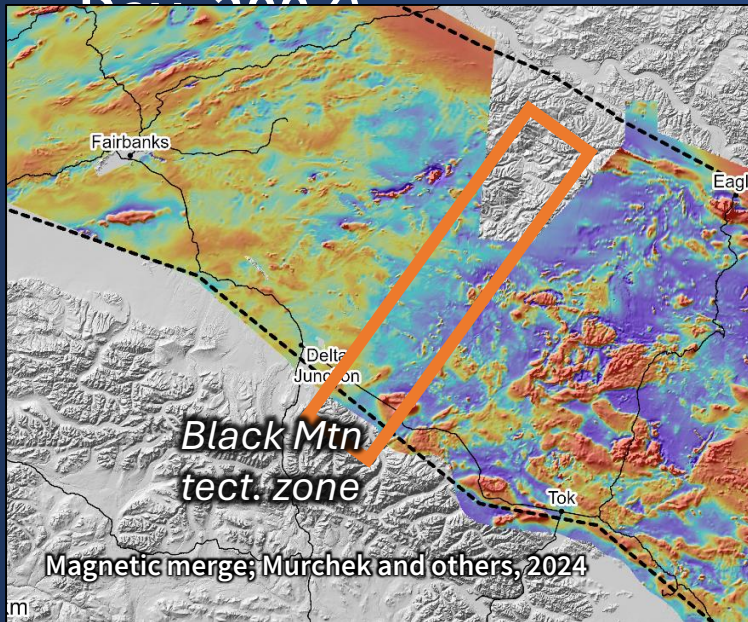
- Field work completed in 2022 and 2033
- Goal is 1:100k scale maps
- Large area incorporating previously published maps
- Includes the boundary between Yukon Tanana Terrane and North America
- Area south of Pogo and surrounding other prospects
- Plan to publish spring 2025 as 1 report + 4 map sheets





# Harper-Richardson Project

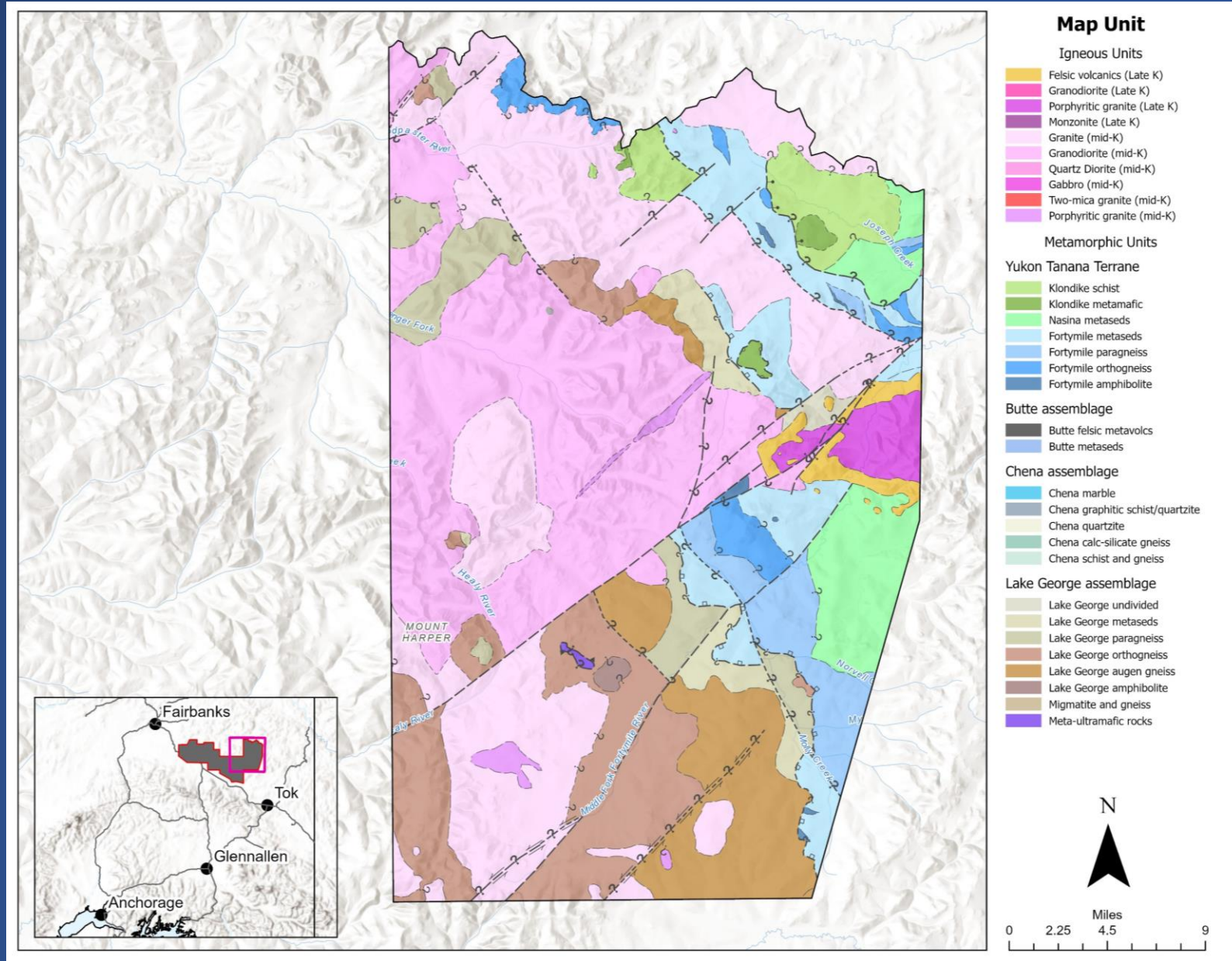
- Northeast-striking high-angle faults and fault zones
- BMTZ separates areas of higher mag (NW side) and lower mag (SE side)
- Higher gravity on the NW side (Saltus and D... 2007)





# Mount Harper-Middle Fork Area

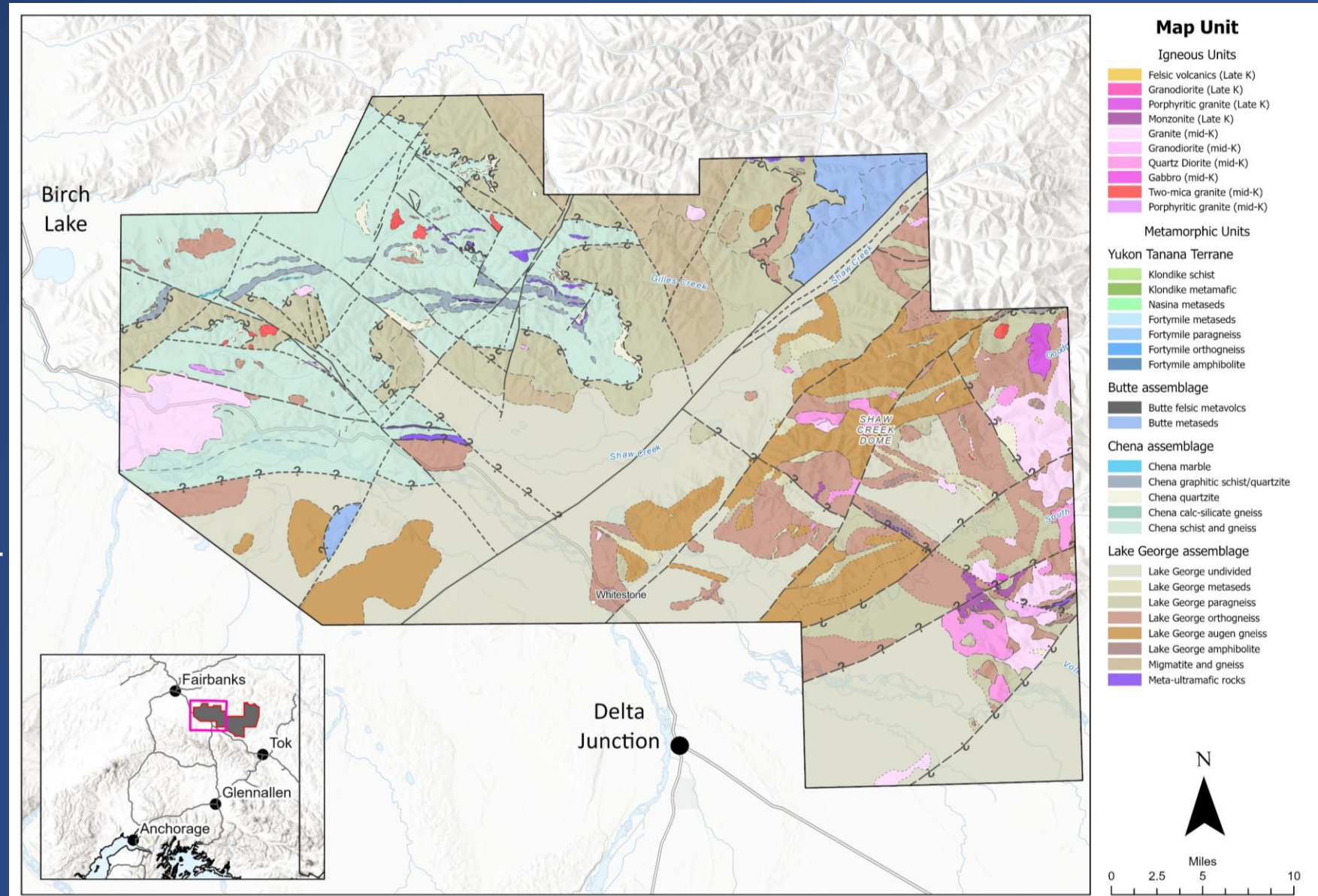
- Yukon Tanana Terrane units at the along eastern edge (blues and greens) including Fortymile R, Nasina, and Klondike assemblages
  - Contact with NA rocks is a low-angle detachment(?) bisected by younger high-angle faults and intrusions
- Harper fault bisects the map area
  - NW side-up exposing Mt. Harper batholith after/during intrusion (ca 105-110 Ma)
  - Slightly younger dikes/porphyritic intrusions parallel to the fault are dated at ~107 Ma and indicate NW-SE extension
  - Continued fault movement after formation of the ~70 Ma Middle Fork caldera





# Shaw Creek-Richardson Area

- Orthogneiss dominates the Lake George assemblage SE of the Shaw Creek fault
- Metasediments NW of the fault are partly assigned to the Chena River assemblage (FBX schist)
  - Contains notable marble, graphitic schist/quartzite, and calc-silicate gneiss
- Butte assemblage (greenschist-facies) mapped NW of fault west of Pogo





# Yukon Tanana Upland compilation project: geochemistry and geochronology

## LOADS OF DATA!

- 20,131 stations in the YTU from 2015-2023
- 2,574 MOX samples from 2015-2023 plus data from the USGS-AGDB4
- 241 Geochronology samples from 2017-2022 plus a few USGS samples
- Future compilation: GX samples, structure data, petrography table, combine contacts/faults and polygons into YTU compilation layers, add older DGGS Geochem/geochron, add other USGS data.

## Focused on igneous geochemistry & geochronology

- 742 igneous samples with either MOX, geochron, or both.
- Start by dividing the igneous samples into suites based on age/geography/chemistry.



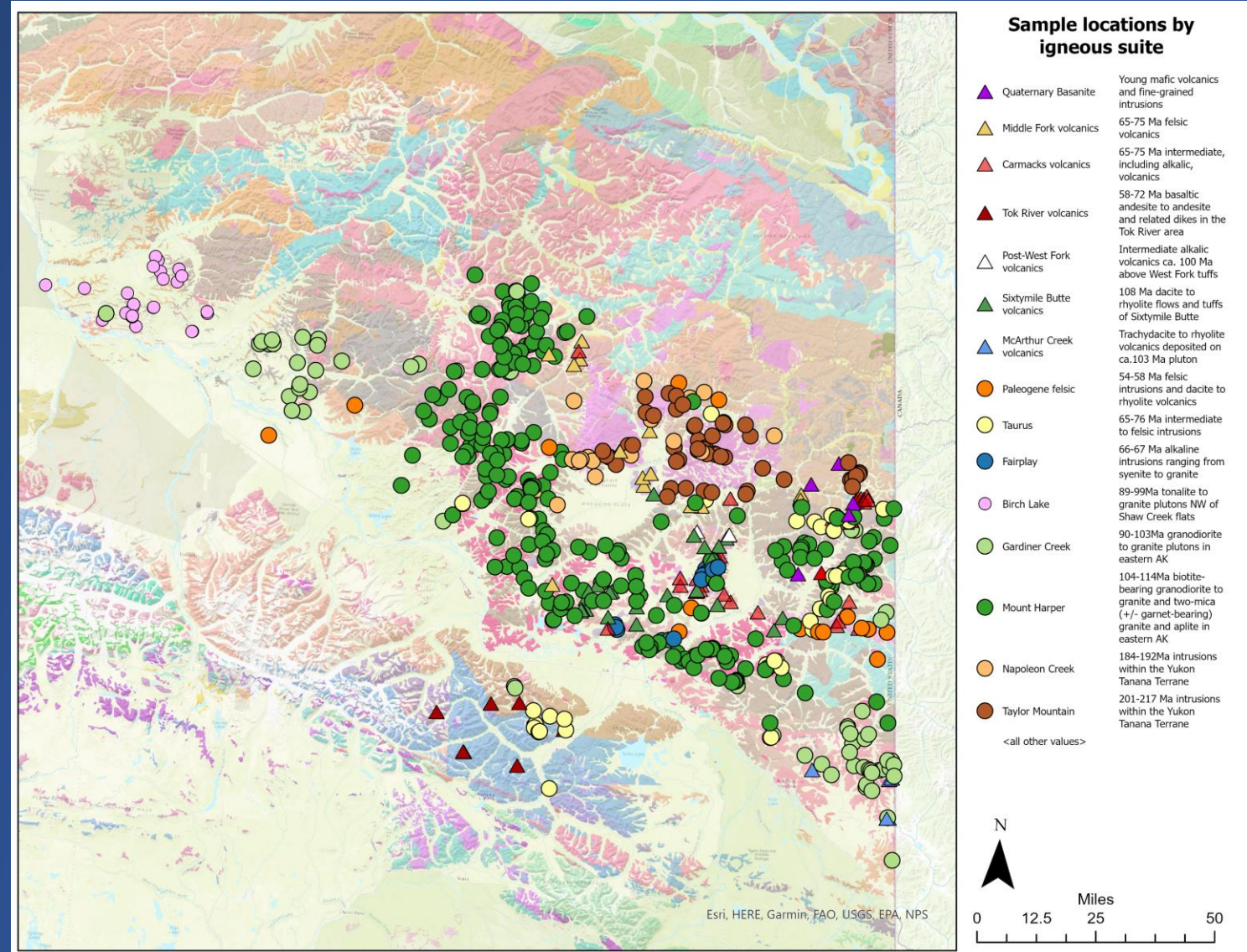
# Volcanic and plutonic suites in YTU

Triassic to Quaternary igneous suites based on:

- What map unit the station is in
- Geochronology
- Sample and/or petrographic descriptions
- Geochemistry

Iterative process to assign samples to each suite based on location, previous mapping, age, geochem

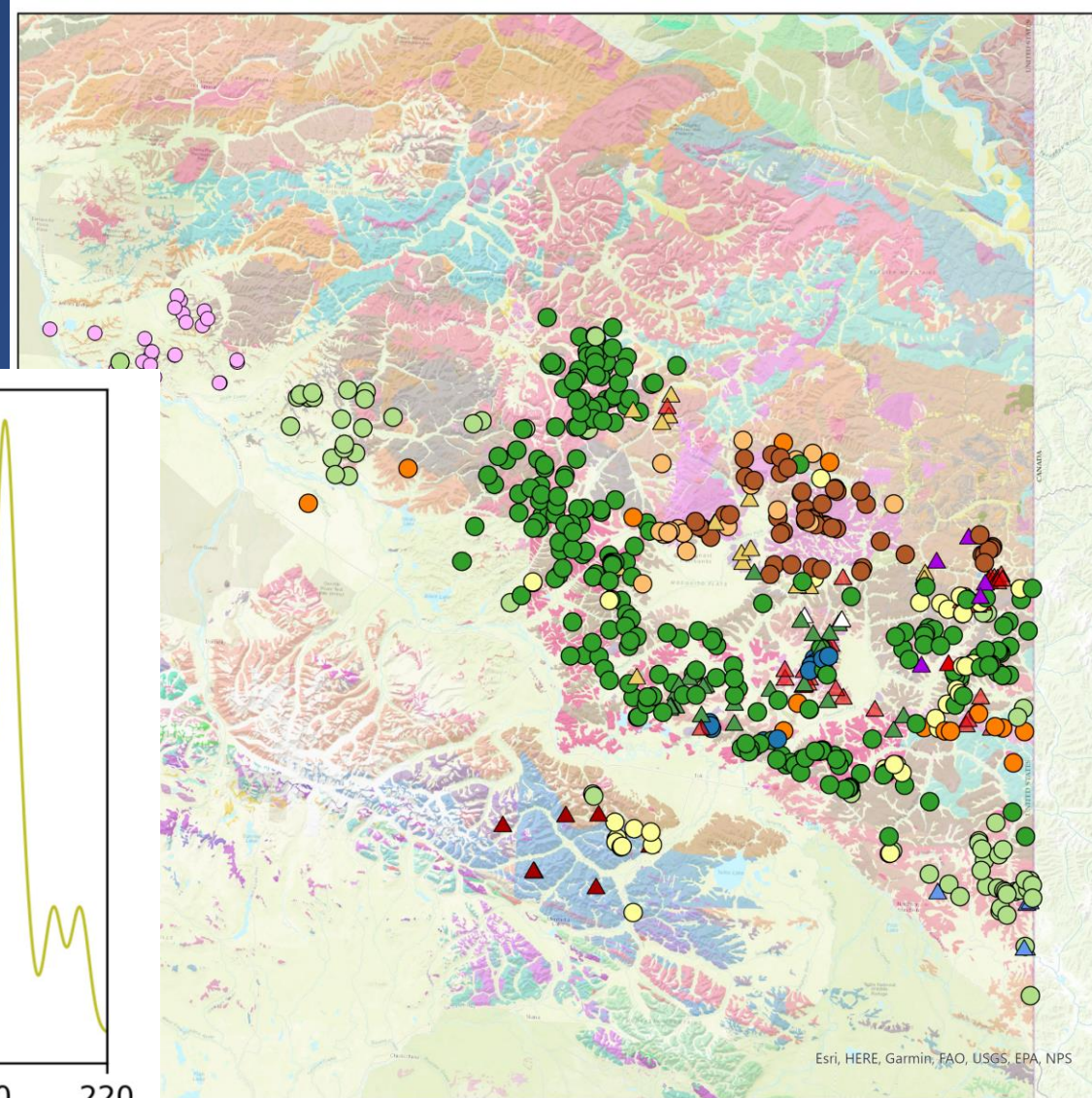
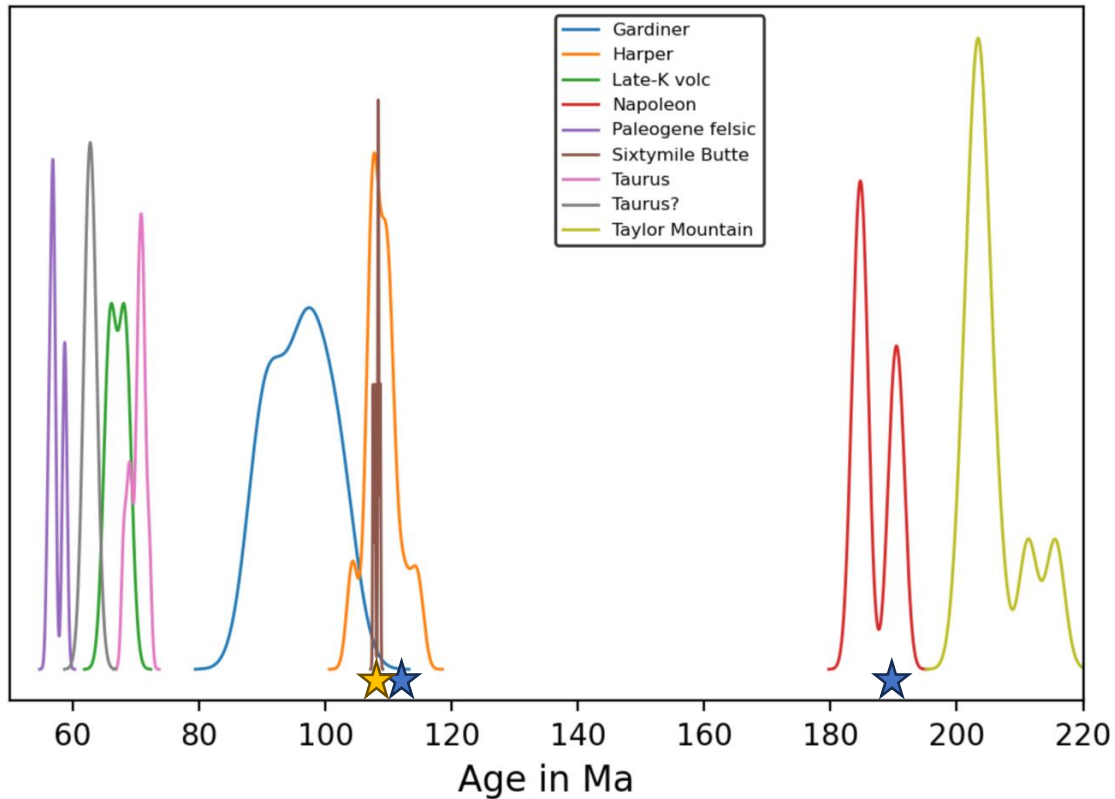
78 of 742 igneous samples with no suite assignment yet. Many are dikes.





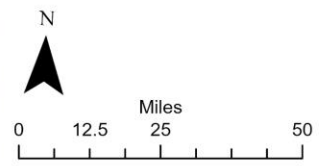
# Volcanic and plutonic suites in YTU

## Magmatic pulses Zircon U-Pb ages



### Sample locations by igneous suite

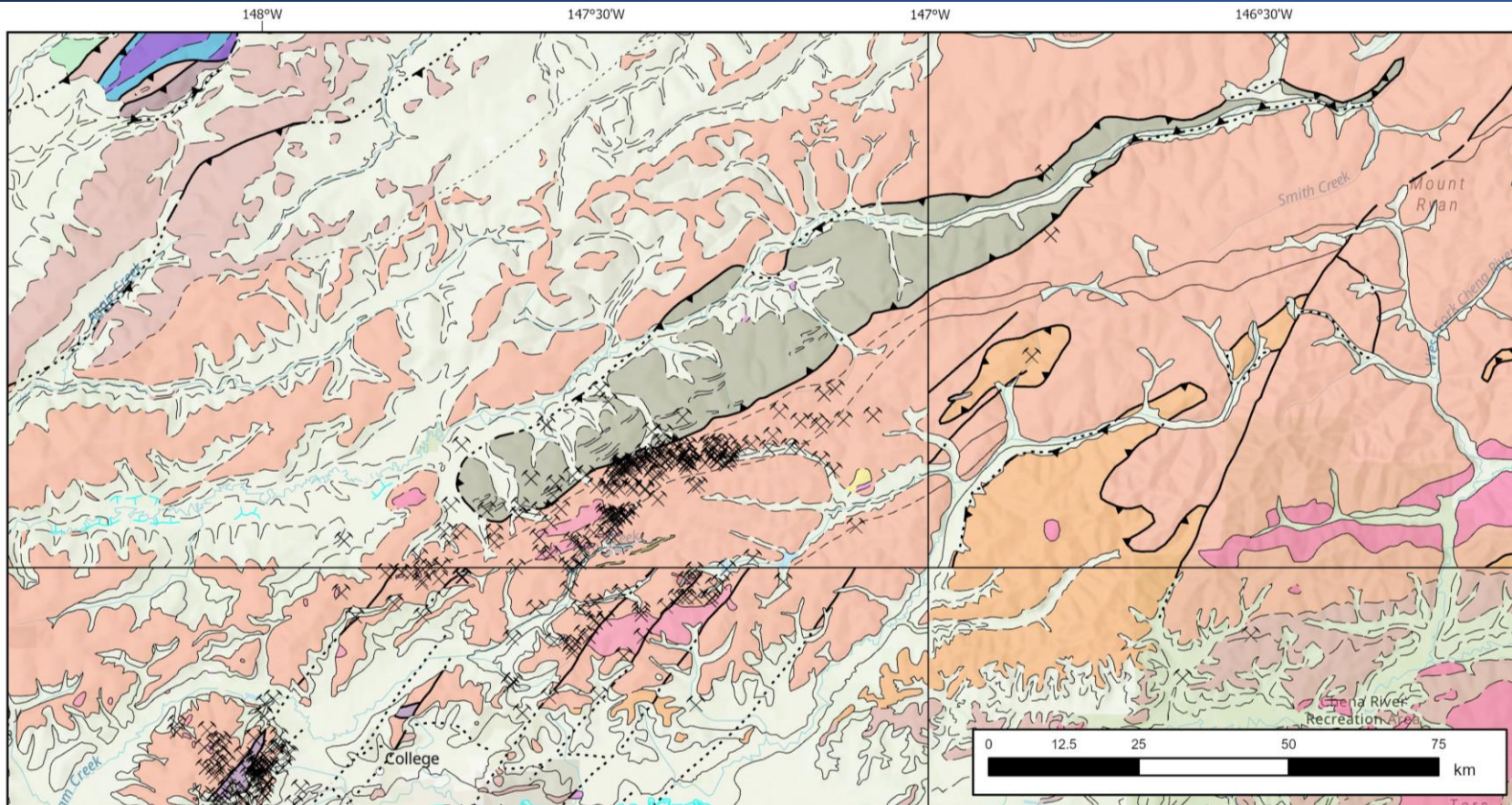
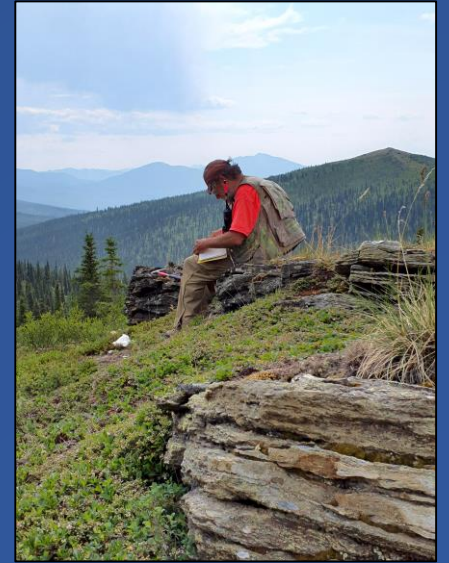
- ▲ Quaternary Basanite: Young mafic volcanics and fine-grained intrusions
- ▲ Middle Fork volcanics: 65-75 Ma felsic volcanics
- ▲ Carmacks volcanics: 65-75 Ma intermediate, including alkalic, volcanics
- ▲ Tok River volcanics: 58-72 Ma basaltic andesite to andesite and related dikes in the Tok River area
- △ Post-West Fork volcanics: Intermediate alkalic volcanics ca. 100 Ma above West Fork tuffs
- ▲ Sixtymile Butte volcanics: 108 Ma dacite to rhyolite flows and tuffs of Sixtymile Butte
- ▲ McArthur Creek volcanics: Trachydacite to rhyolite volcanics deposited on ca.103 Ma pluton
- Paleogene felsic: 54-58 Ma felsic intrusions and dacite to rhyolite volcanics
- Taurus: 65-76 Ma intermediate to felsic intrusions
- Fairplay: 66-67 Ma alkaline intrusions ranging from syenite to granite
- Birch Lake: 89-99Ma tonalite to granite plutons NW of Shaw Creek flats
- Gardiner Creek: 90-103Ma granodiorite to granite plutons in eastern AK
- Mount Harper: 104-114Ma biotite-bearing granodiorite to granite and two-mica (+/- garnet-bearing) granite and aplite in eastern AK
- Napoleon Creek: 184-192Ma intrusions within the Yukon Tanana Terrane
- Taylor Mountain: 201-217 Ma intrusions within the Yukon Tanana Terrane
- <all other values>





# Chatanika Eclogite Terrane – The Problem

- Complex structural juxtaposition with amphibolite facies
- Schist > Paragneiss > Quartzite >>>> Eclogite
- Metamorphic rocks inside and adjacent to the terrane look similar

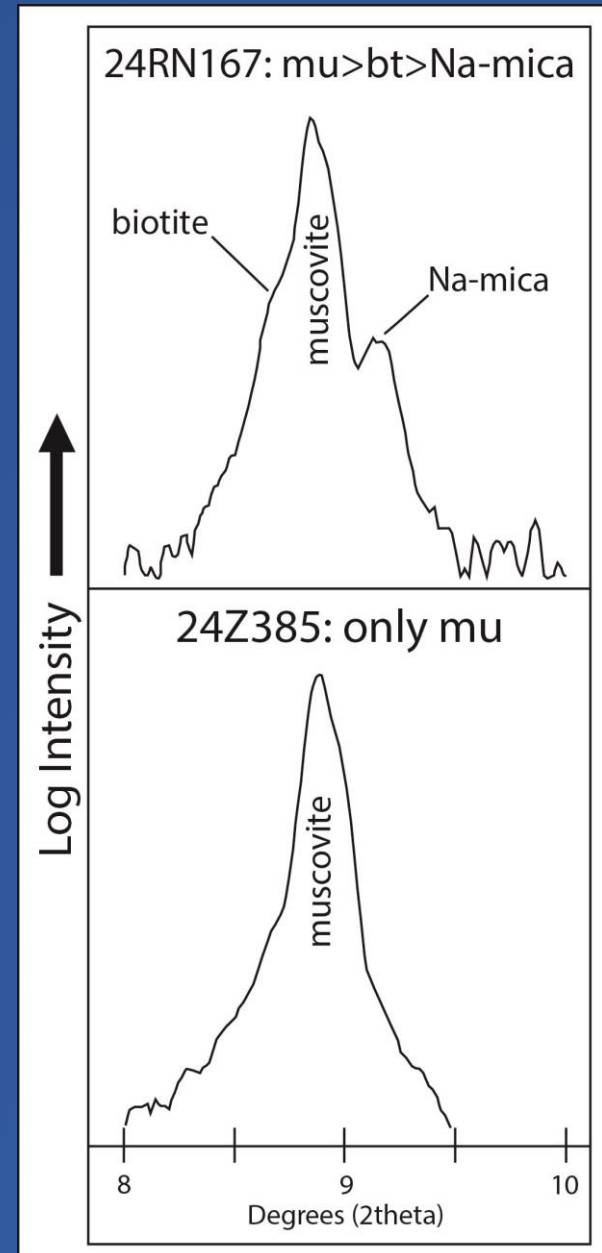
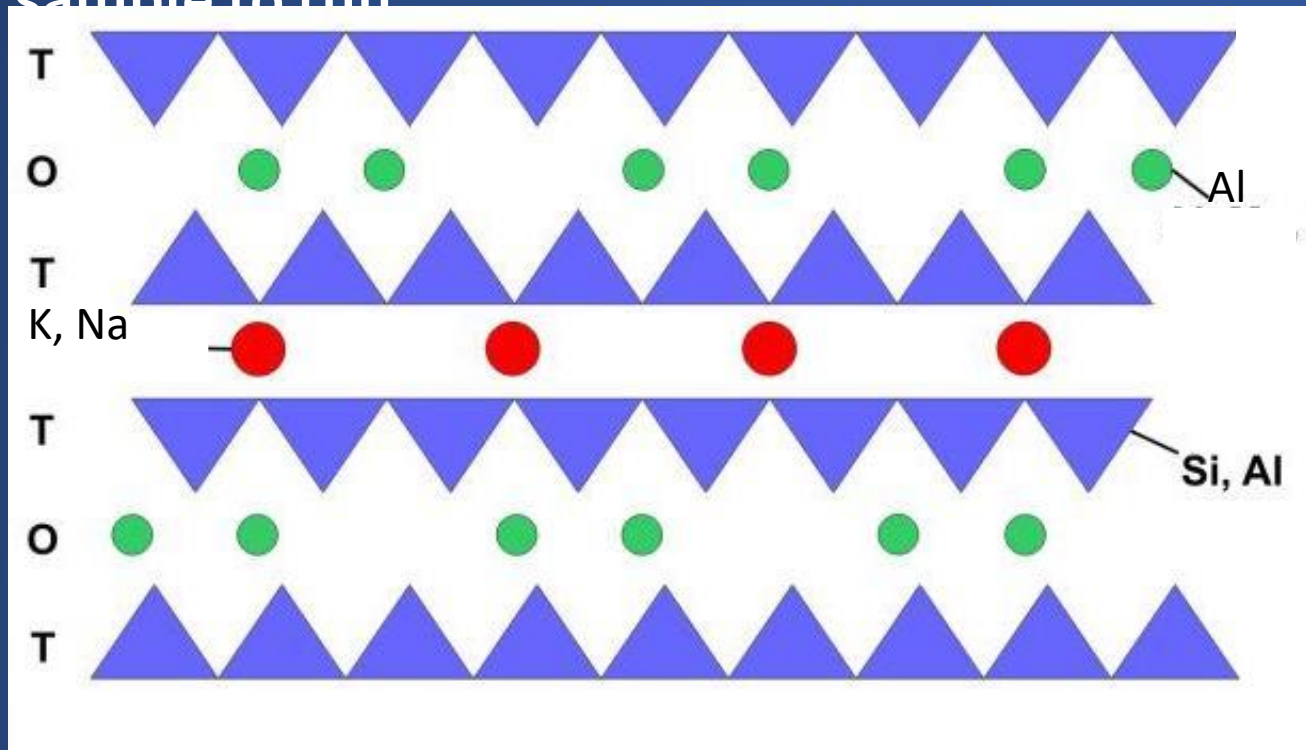
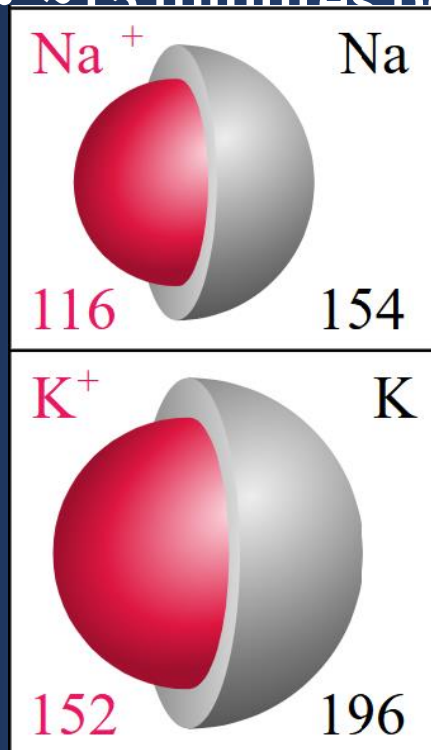


Wilson and others, 2015



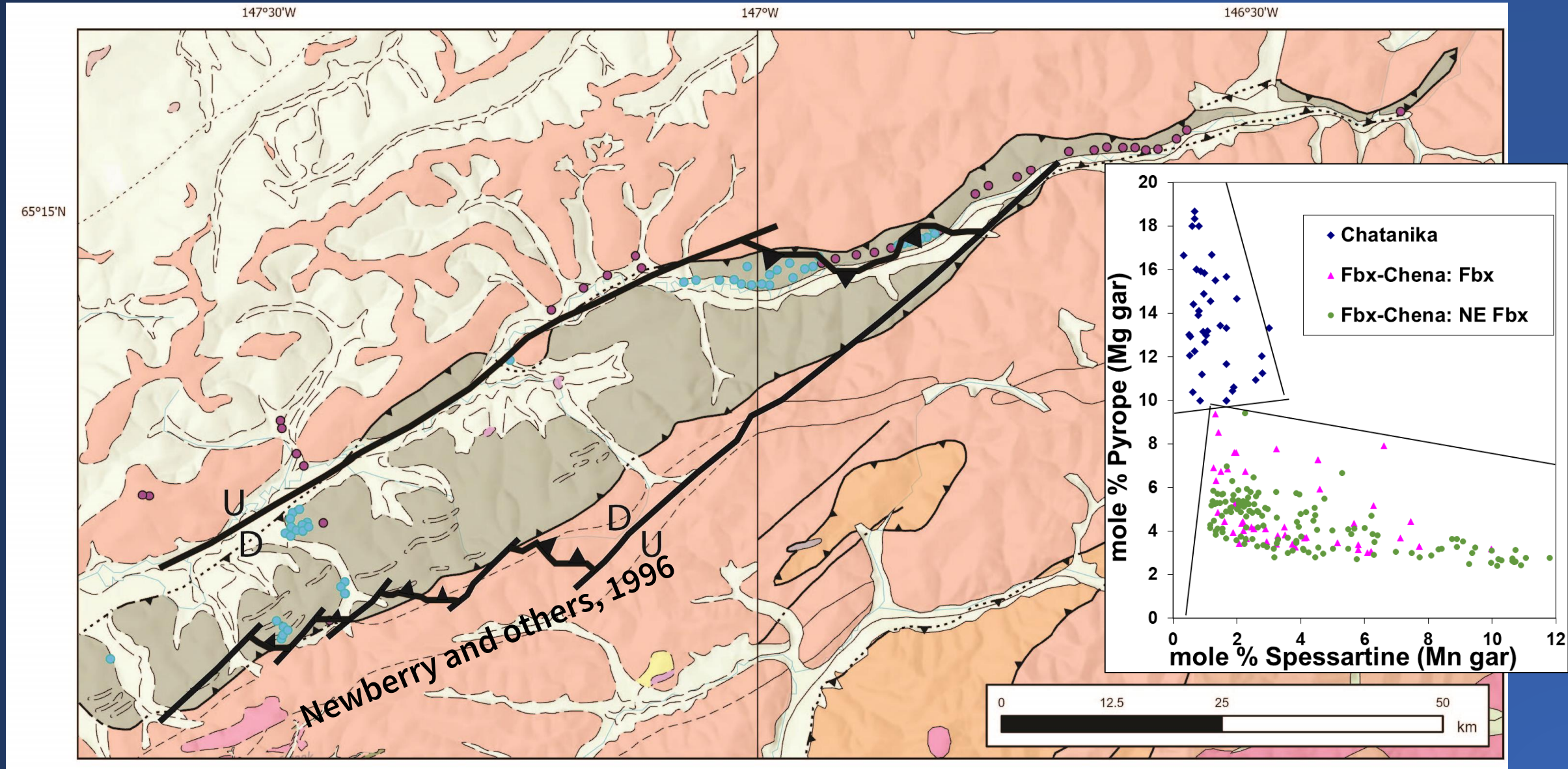
# Chatanika Eclogite Terrane – Paragonite – Na-mica

- Difference in ionic radii of Na and K causes change in crystal lattice
- Can be measured by X-Ray Diffraction of powdered rock sample
- Little solid solution between paragonite and muscovite; if peak is present then paragonite is present
- ~15 minutes per sample to run





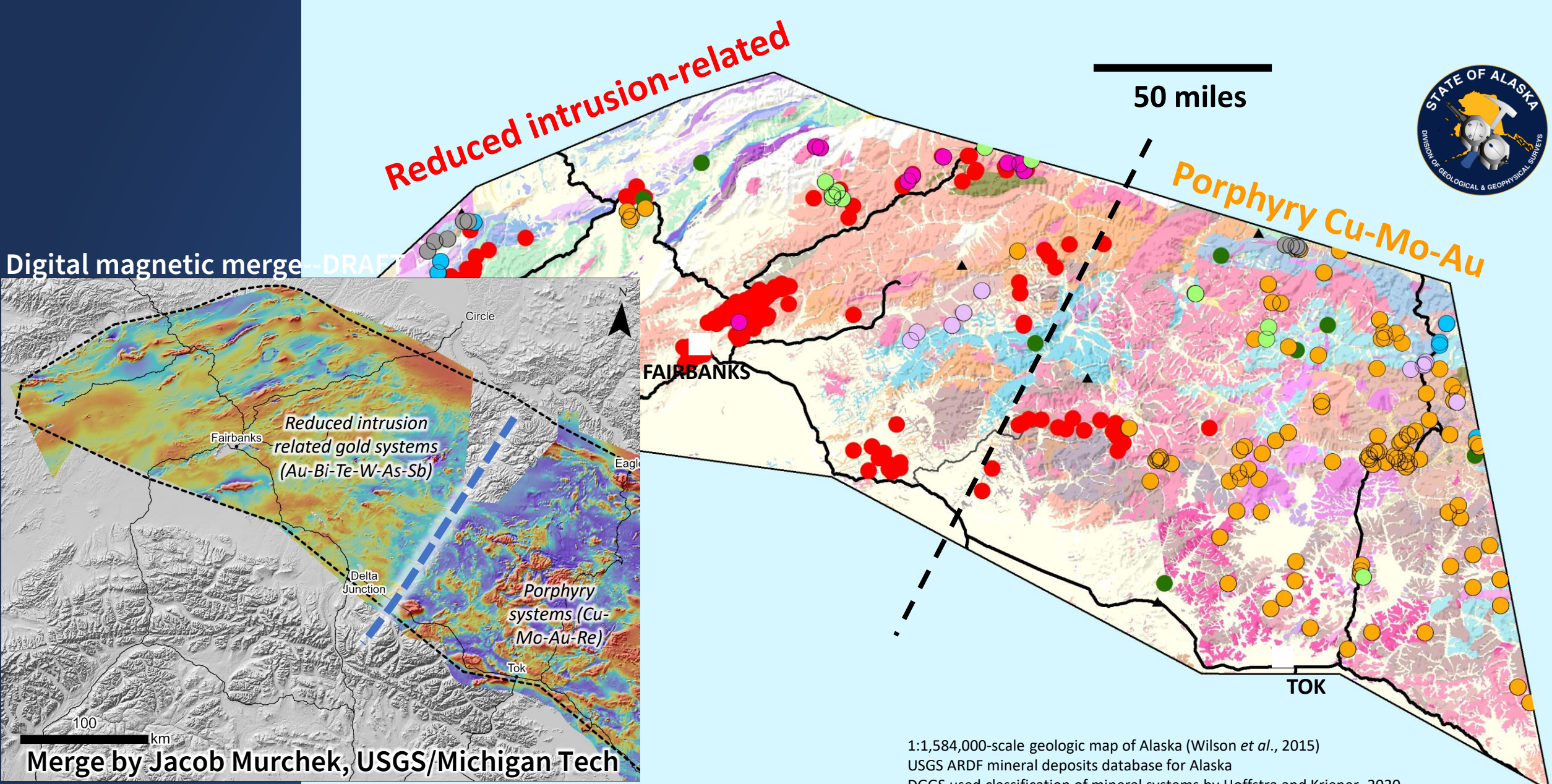
# Chatanika Eclogite Terrane – Updated Boundary



Compiled geology of Wilson and others, 2015



# The Big Picture



Merge by Jacob Murchek, USGS/Michigan Tech

1:1,584,000-scale geologic map of Alaska (Wilson *et al.*, 2015)  
USGS ARDF mineral deposits database for Alaska  
DGGs used classification of mineral systems by Hoffstra and Kriener, 2020



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## Geologic Mapping Publications

### Recently Published

- 2023 Chena Station Data

### Upcoming

- Taylor Mountain and Western Tanacross geologic maps
- 2023 Chena Geochemical Data
- 2022 Harper Geochronology

## Geophysics Publications

- Best place to get data: <https://maps.dggs.alaska.gov/gp/>
- Brand new
  - Seward Peninsula Electromagnetic data <https://doi.org/10.14509/31303>
- Recently published
  - Kuskokwim Sischu magnetic and radiometric survey - <https://doi.org/10.14509/31094>
  - Yukon Tanana Magnetic Merge (USGS) <https://doi.org/10.5066/P14UWTR3>
- Upcoming
  - Kaiyuh EM, Kaiyuh mag/rad
  - Tofty mag/rad
  - Northern and Central Kuskokwim gravity
  - Central Kuskokwim mag/rad





# Never a bad day in the field...

