New Data and Insight on the Late Triassic Wrangellia Magmatic Ni-Cu-Co-PGE System in the Talkeetna Mountains, Central Alaska

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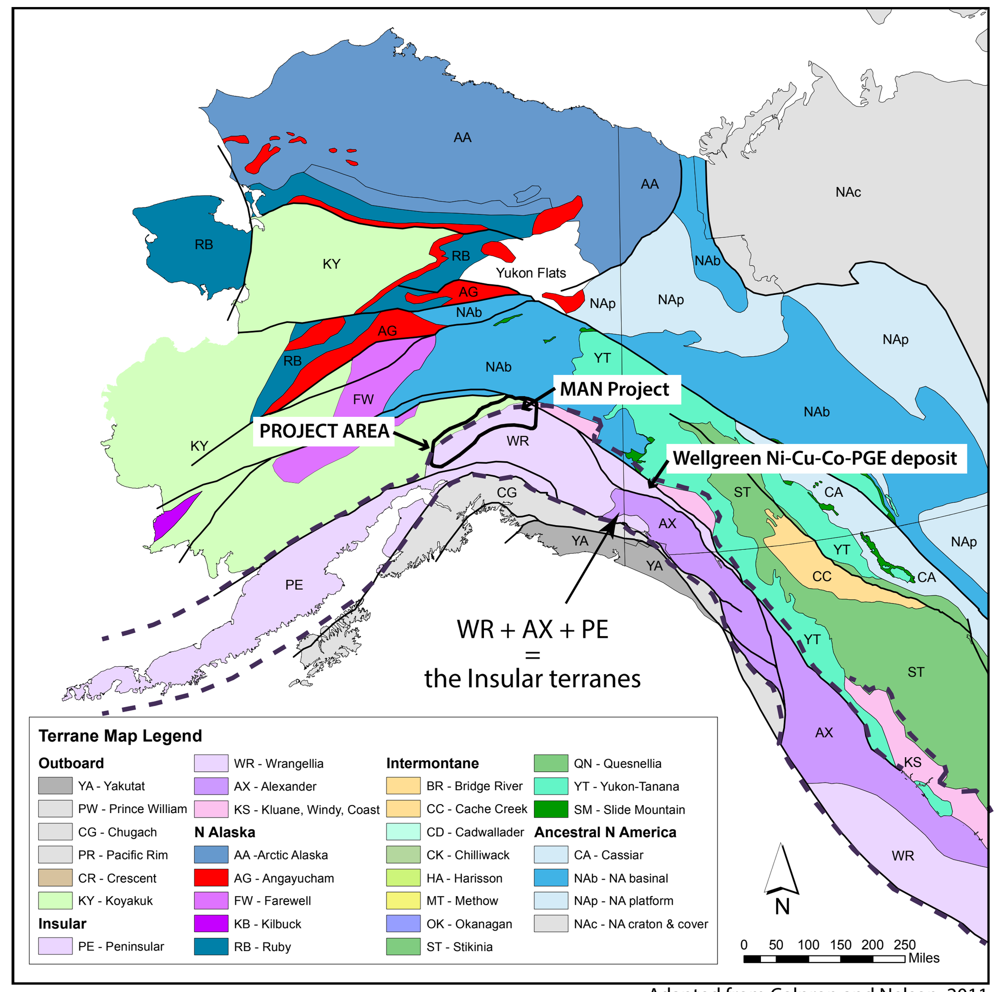
Project Location and Terrane Map



Adapted from Colpron and Nelson, 2011

Abstract

Ni-Cu-Co-PGE mineralization occurs as magmatic sulfides in Late Triassic mafic-ultramafic intrusions of the Wrangellia terrane in Alaska and the Yukon. Parts of this metallogenic system have seen detailed study and exploration, notably at the Quill Creek Complex and Wellgreen deposit in the Yukon Territory, and at several prospects in the Eastern Alaska Range, including the Alpha Complex. Recent mapping in the Talkeetna Mountains showed that these mafic-ultramafic intrusions and their extrusive equivalent, the Nikolai Greenstone Large Igneous Province (LIP), continue at least 60 km to the southwest of the previously recognized extent. This opens up geologic potential for magmatic Ni-Cu-Co-PGE deposits to occur in the Talkeetna Mountains of central Alaska.

As part of its ongoing Airborne Geophysical/Geological Mineral Inventory and Strategic and Critical Minerals Assessment programs, the Alaska Division of Geological and Geophysical Surveys (DGGS) initiated a multi-year project to improve the understanding of mineral potential in western Wrangellia. The project began in 2013 with acquisition of magnetic and electromagnetic (EM) geophysical data over unsurveyed portions of the terrane in the Clearwater and Talkeetna Mountains. DGGS geologists completed a three week field program of geologic mapping, rock, and stream sediment sampling in 2013, and followed up with 1:50,000-scale mapping of the Talkeetna Mountains C-4 Quadrangle during the 2014 field season.

Gabbroic and ultramafic rocks of probable Late Triassic age were sampled across the project area. Previous work divides the Nikolai Greenstone into a stratigraphically lower, depleted mantle-derived, low TiO_2 group and an upper, enriched mantle-derived, high TiO_2 group. Both intrusive and extrusive members of this earlier petrogenetic suite occur throughout western Wrangellia. DGGS investigations indicate that PGE enrichment is associated only with the earlier, low TiO_2 suite.

Outside of the Mount Hayes Quadrangle, the most prominent low-TiO_2 type mafic-ultramafic complex is the 16 km long, up to 700m-thick sill-form body in the northeastern Talkeetna Mountains south of Butte Creek. Mapping and analytical work indicate that this is a multiphase intrusive complex dominated by gabbro to olivine gabbro, with texture varying from fine-grained to pegmatitic. The thickest, most mafic section shows large-scale gradational variation in mineralogy from olivine-rich troctolite at the center to olivine gabbro above and below, apparent differentiation which is similar to that seen at the Quill Creek Complex.

Microprobe results show that olivine grains near the base of this intrusive complex have Ni concentrations around 2900 ppm, whereas olivine in the center of the complex average 1100 ppm Ni. This apparent Ni depletion is comparable to that observed at Wellgreen. Sulfide grains, including intergrown pyrrhotite and pentlandite, were found to occur at grain interstices and as rare inclusions in Ni-depleted olivine.

Analyses from the northeastern half of the study area yield values of PGE per 100 percent sulfide that are on par with values for the Wellgreen deposit. These data, along with the olivine Ni depletion, imply an early separation of a sulfide melt and a high degree of sulfide-silicate melt interaction, indicating that this part of Wrangellia has completed important prerequisites for the formation of Ni-Cu-Co-PGE deposits.

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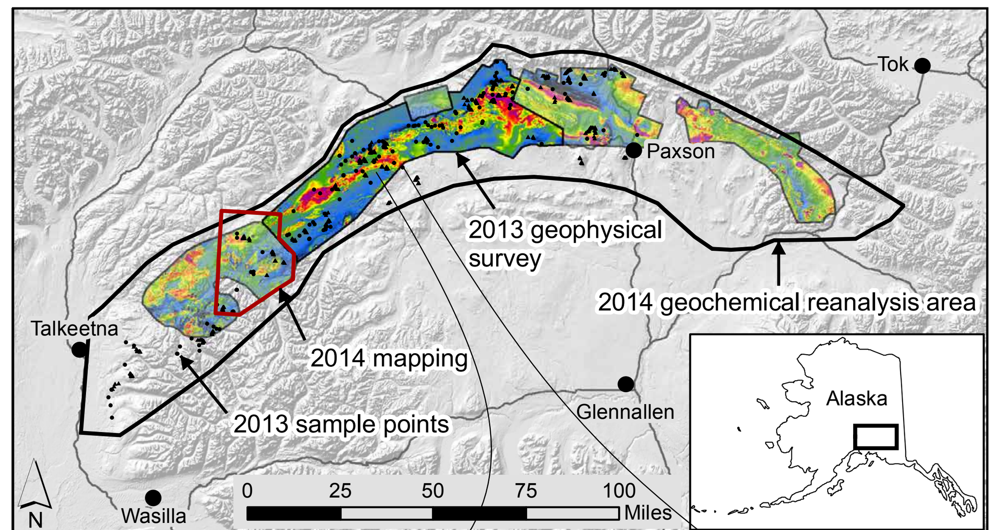
Overview

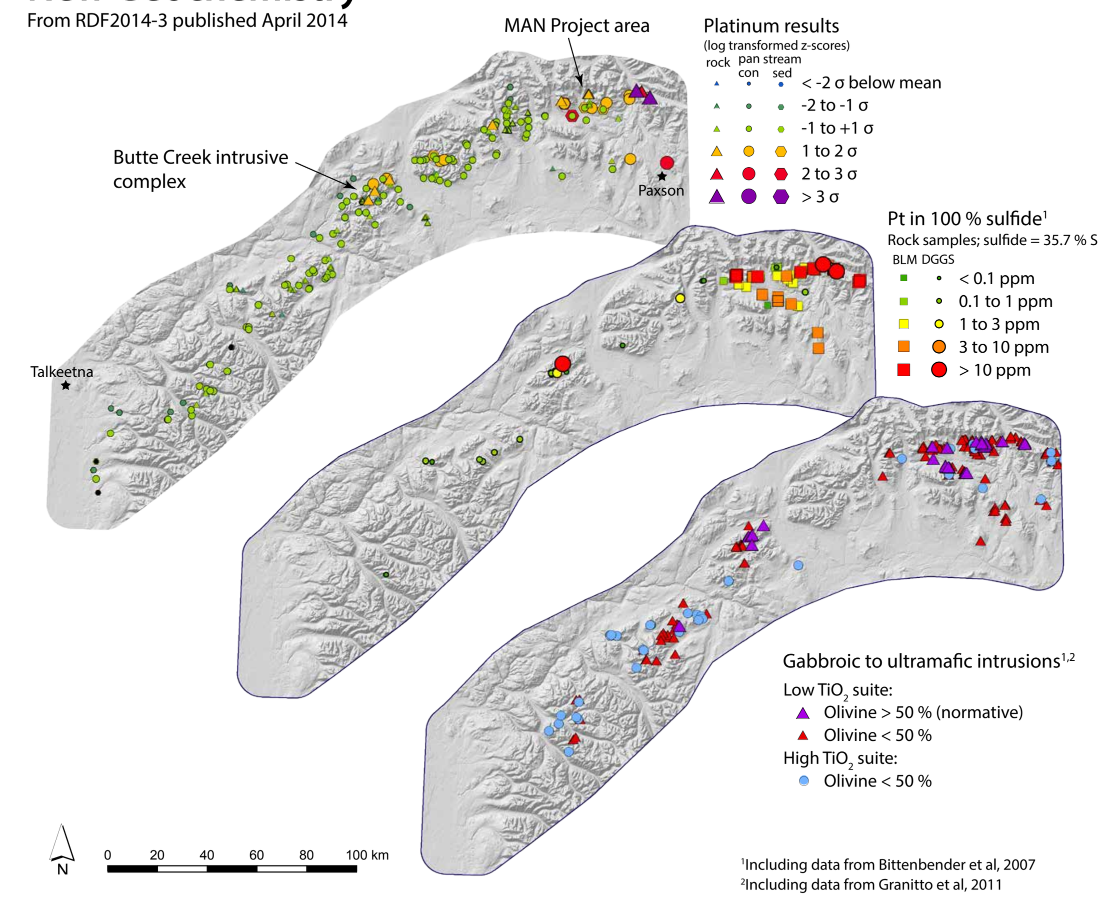
A multi-part, multi-year program:

- 1400 square miles of new airborne magnetics and EM geophysics flown in 2013
- Modern reanalyses of ~1600 stream sediment pulps in cooperation with the USGS
- New geochemical sampling and targeted mapping
- New Talkeetna Mountains C-4 quadrangle map through USGS STATEMAP program
- Additional 1:50,000-scale geologic mapping and map revisions
- Related applied scientific research



New Geochemistry

From RDF2014-3 published April 2014



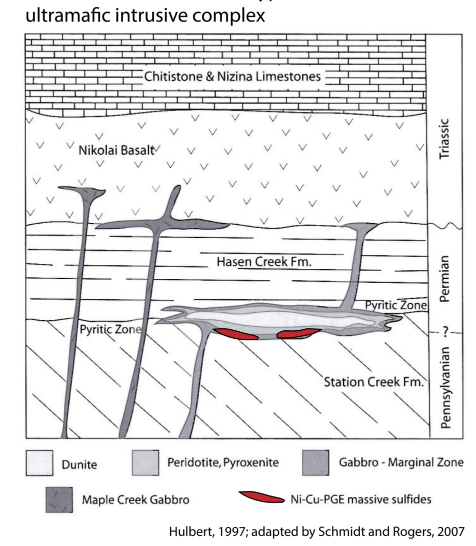
Wellgreen magmatic Ni-Cu-Co-PGE deposit, Yukon

A potential analog for Late Triassic mineralization in western Wrangellia

Geologic characteristics of Wellgreen and the Kluane-area prospects:

- Late Triassic age (ca. 224-232 Ma)
- Sill-form, intruding Permian sediments; Quill Creek complex is 4.2 km long, 600m thick
- Differentiated, with gabbroic margins grading to clinopyroxenite and dunite core
- Clinopyroxene >> orthopyroxene
- Intrusions are low TiO_2; linked to the early, low-Ti basalt suite of Greene et al (2008)
- Pt and Pd concentrations subequal
- Pt content per 100 % sulfide: 4-12 ppm (Hulbert, 1997)

Schematic cross section of typical Kluane mafic-ultramafic intrusive complex



Hulbert, 1997; adapted by Schmidt and Rogers, 2007

Resource and production:

1970-1973: limited production from massive sulfides

Massive sulfide outcrop at the Wellgreen property

Current resource:

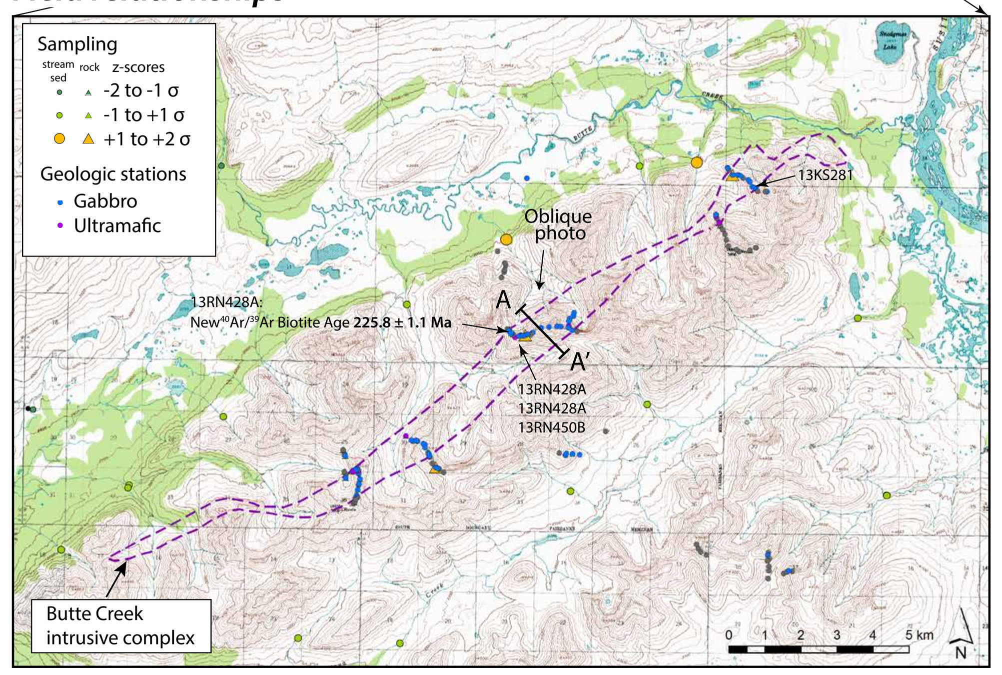
Disseminated to massive sulfide in open pit scenario; 0.15 % Ni Eq cut-off:

	Tonnes	Pt g/t	Pd g/t	Au g/t	Ni %	Cu %	Co%
Total M & I:	330M	0.237	0.240	0.045	0.261	0.141	0.015
Inferred:	846M	0.234	0.226	0.047	0.237	0.139	0.015

(Wellgreen Platinum press release July 24, 2014)

Highlight: Butte Creek intrusive complex

Field relationships

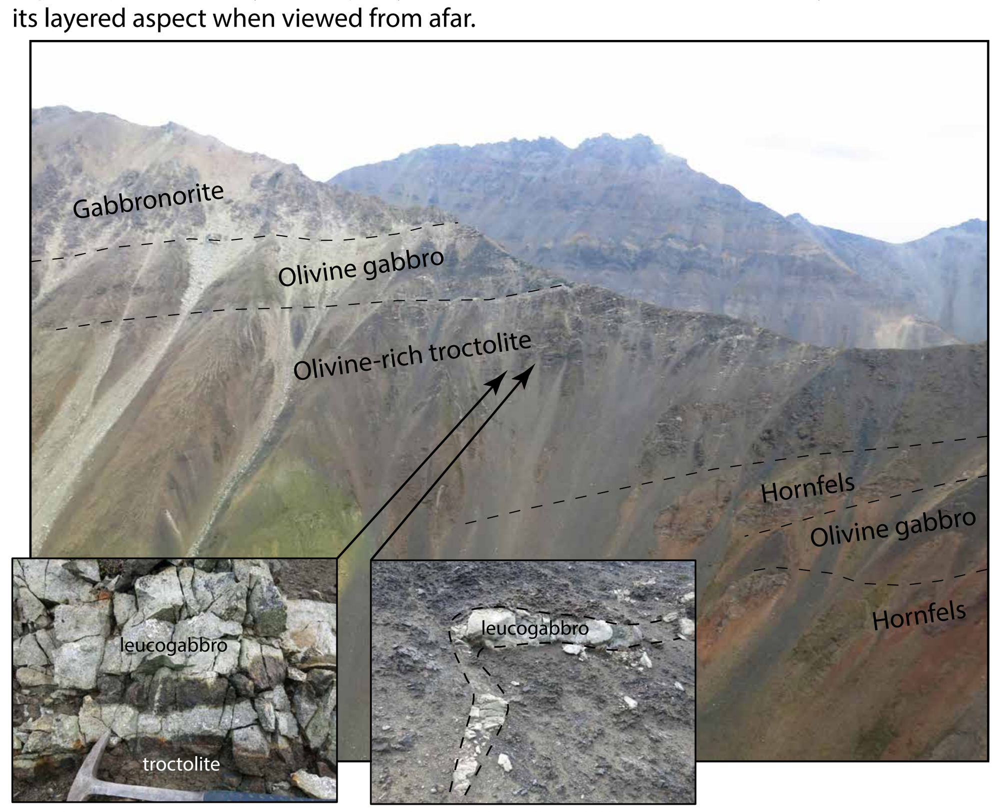


DGGS geologists completed targeted traverses across areas of known or suspected Late Triassic gabbroic to ultramafic intrusions.

One outcome was improved data regarding the extent, thickness, and petrology of the informally-named Butte Creek intrusive complex in the northeastern Talkeetna Mountains.

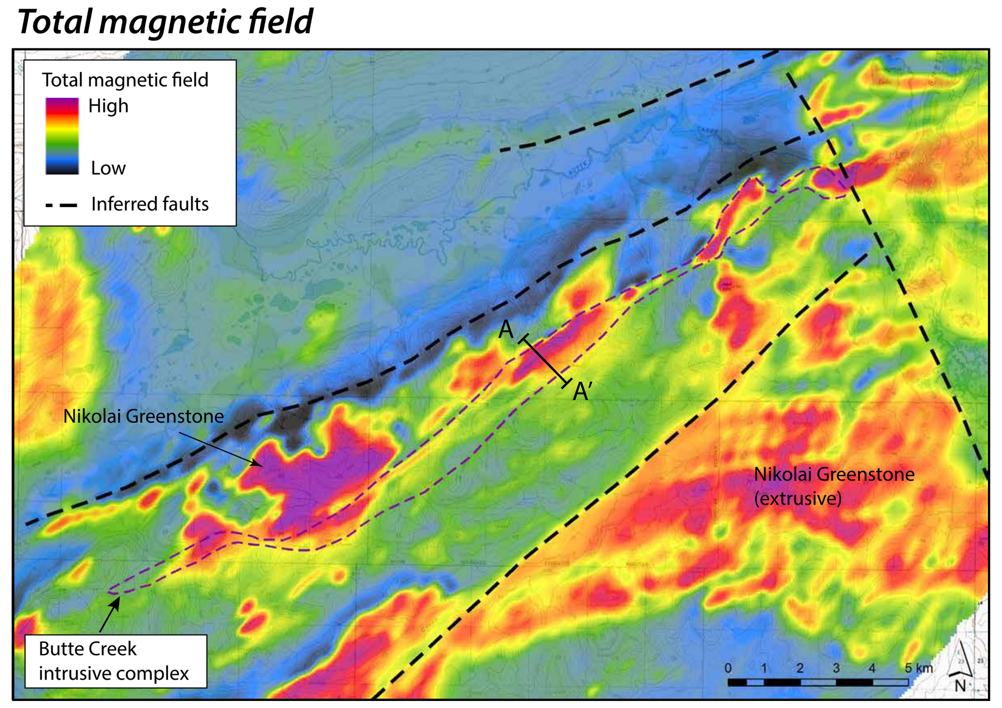
The purple outline above and at right highlights the complex based on 2013 fieldwork, geophysics, and previous mapping.

Oblique photo looking south showing the Butte Creek intrusive complex. Existing geologic maps misidentify the majority of complex as Paleozoic sedimentary rocks due to its layered aspect when viewed from afar.



Cumulate layering? ...or leucogabbro sills and dikes?

Total magnetic field



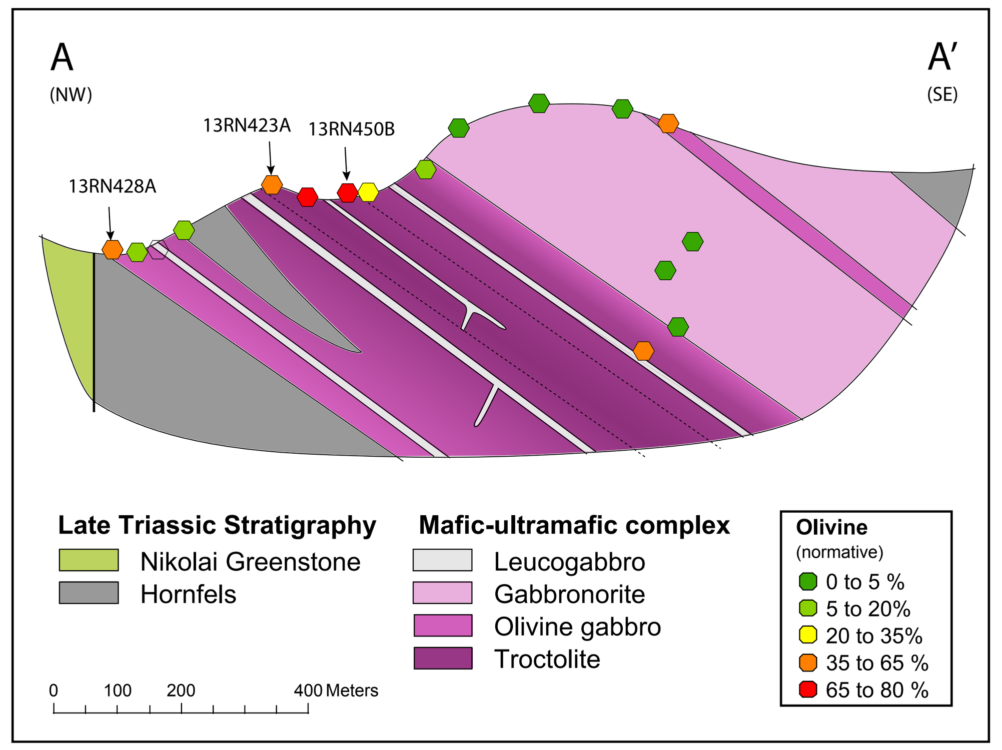
New aeromagnetic data (GPR2014-1; Burns et al, 2014) highlights only the most mafic (and serpentinized) portions of the Butte Creek intrusive complex; magnetic highs reflect the distribution of the upper, high-TiO_2 member of the extrusive Nikolai Greenstone.

The survey also reveals major faults, many of which are not shown on existing maps.

Cross section

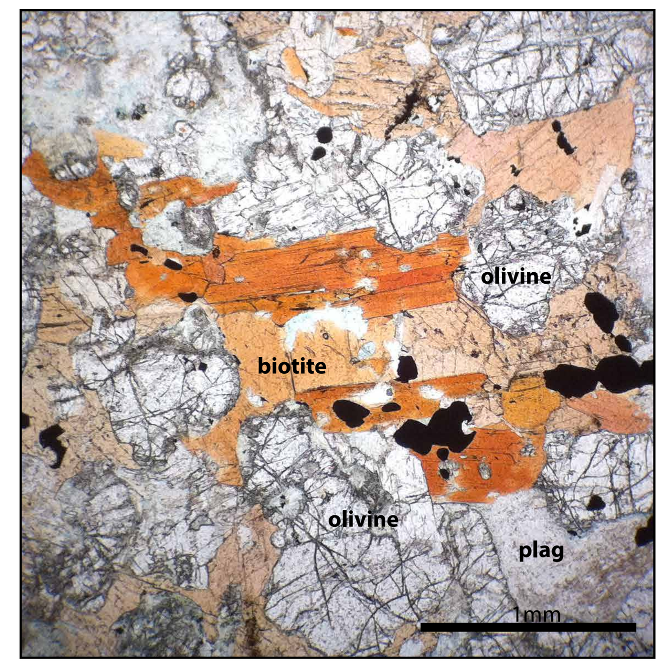
Multiple traverses across the complex indicate that this is a multiphase gabbroic sill complex approximately 700m thick.

The most mafic phase (olivine gabbro to melanocratic troctolite) is progressively more mafic towards its center.

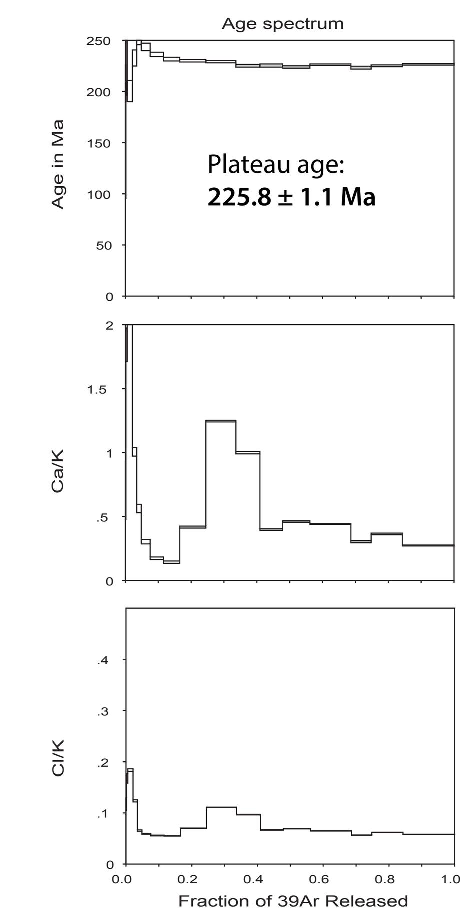


Geochronology

Biotite-bearing olivine gabbro (13RN428A) from the Butte Creek intrusive complex yields a **Late Triassic age of 225.8 ± 1.1 Ma** (Benowitz et al, 2014).

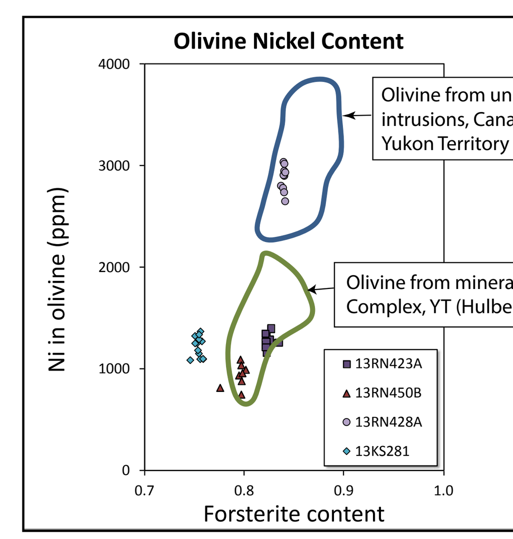


Photomicrograph (plane polarized light) showing intercumulus biotite used to date olivine gabbro in the Butte Creek intrusive complex.

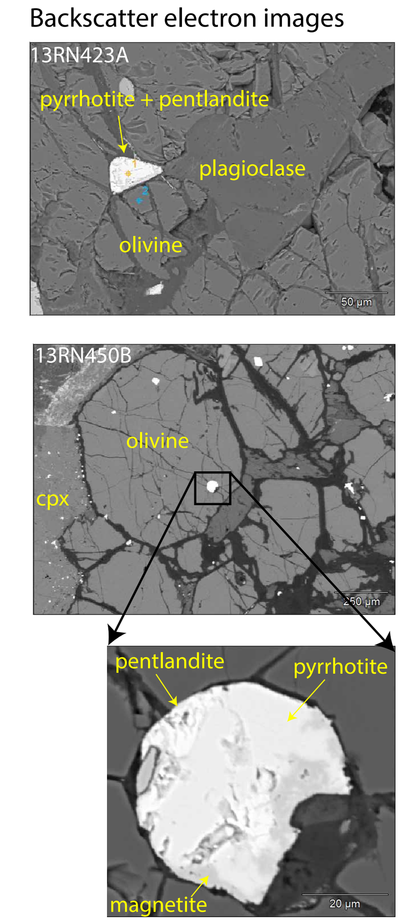


Microprobe Data

- Olivine compositions from troctolite near the center of the Butte Creek complex have Ni-depleted compositions that are similar to those found at the Wellgreen deposit.
- Olivine compositions at the base of the complex (earliest magma?) have undepleted Ni-contents.
- Backscatter electron imagery shows blebs of intergrown Fe and Ni sulfides at grain boundaries and as inclusions in olivine.



Backscatter electron images



Discussion: Ni-Cu-PGE potential

Do the Late Triassic intrusions in the Talkeetna Mountains have the potential to produce an economic magmatic Ni-Cu-Co-PGE deposit?

PGEs etc. are enriched in the mantle- The **first challenge** is to extract magma from the mantle without losing the Ni, Cu, PGEs

Three possible scenarios:

A) Sulfide saturation at a deep level: PGE, Cu, Ni not extracted with melt

B) Olivine saturation and crystallization at a deep level: Ni not extracted

C) Sulfide, olivine are undersaturated until high level emplacement: Sulfide melt can separate and interact with silicate melt

The **second challenge** is to physically concentrate the sulfide melt in economic quantities

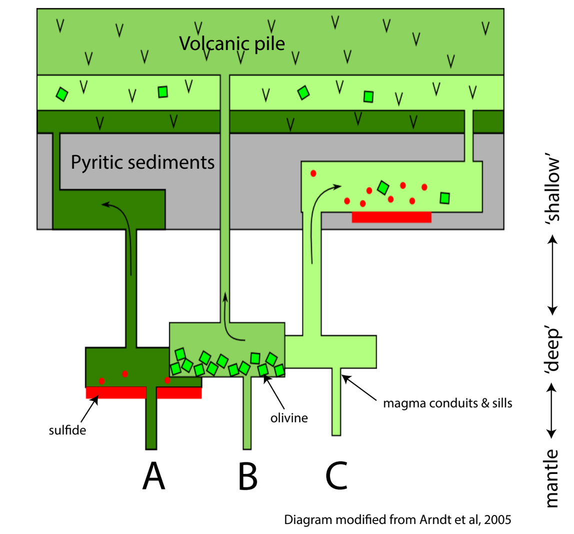


Diagram modified from Arndt et al, 2005

At the Butte Creek intrusive complex in the Talkeetna Mountains:

- Olivine from the base of the complex (crystallized early?) shows no Ni depletion, suggesting that it crystallized **prior** to separation of sulfide from the magma.
- Olivine towards the center of the complex is depleted in Ni suggesting it crystallized **after** the exsolution of sulfide melt.
- Blebs of magmatic Fe-Ni sulfide minerals are observed at grain boundaries and as inclusions in olivine, indicating that a sulfide melt exsolved prior to olivine crystallization.
- While Cu, Ni and PGE grades in DGGS samples are subeconomic, the total sulfide contents are also very low. The calculated tenor of the sulfide at Butte Creek reaches PGE per 100 % sulfide values comparable to those found at Wellgreen.

Conclusions

The Butte Creek intrusive complex in the northeastern Talkeetna Mountains is broadly similar to the Quill Creek complex in the Yukon Territory:

- Late Triassic age
- Low TiO_2 content linked to early phase of Nikolai LIP magmatism
- 500-1000 m thick, multi-kilometer strike length
- Multiphase to differentiated sill-form mafic and locally ultramafic intrusive complex

Additionally, the magmatic system at Butte Creek appears to have undergone some of the prerequisite processes for formation of an magmatic sulfide ore deposit:

- Exsolution of Fe-Ni sulfide phase prior to olivine crystallization
- Interaction of sulfide with large amounts of silicate magma

The system appears to be prospective, but discovery may hinge on the location of a physical trap where sulfide has been able to accumulate.

Geophysics, geochemistry, and geochronology data are available online at: **http://www.dggs.alaska.gov/pubs/**

Acknowledgments

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This poster has not been reviewed for technical content or for conformity to the editorial standards of the DGGS

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