Rare-Earth Element (REE) Potential in the Ray Mountains Area, Central Alaska

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Project Overview

Background

- The Ruby Batholith, located within the Ray Mountains and Hodzana Uplands, is a Cretaceous monzogranitic unit that contains numerous plutons. This study will focus on ten of these plutons.
- This area has been investigated for the past few decades. There are several reports of anomalous Sn, W, Nb, Ta and rare-earth elements (REEs) (Barkey and Foley, 1986; Barker 1992).
- The rare-earth-bearing minerals, allanite, monazite and xenotime, have been identified in heavy mineral panned concentrates as well as the Ruby Batholith granites.

Purpose

- Assess the REE potential within the Ray Mountains area as part of Alaska's Strategic and Critical Minerals (SCM) Assessment Program.
- Locate sources of elevated REEs.
- Characterize the mineralogy of the plutons.

Methods

- Extensive, helicopter-supported geologic mapping and sampling, including whole-rock, gravels, stream sediments, and heavy mineral panned concentrates.
- Modal analyses via chemical stains, petrography, geochronology, major-oxide and trace element analyses, slab XRF analyses, electron probe microanalysis (EPMA) wavelength dispersive spectroscopy (WDS) routines and elemental mapping, initial Sr isotopic ratios.

Rare-Earth Elements

Y	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu

- Light Rare-Earth Elements (LREEs)
- Heavy Rare-Earth Elements + Y (HREYs)

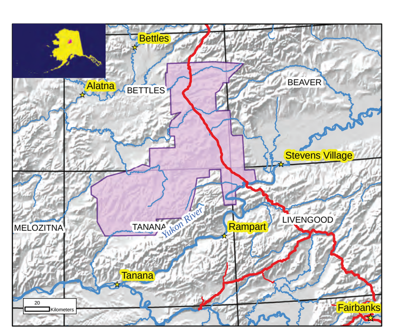
Mineralogy

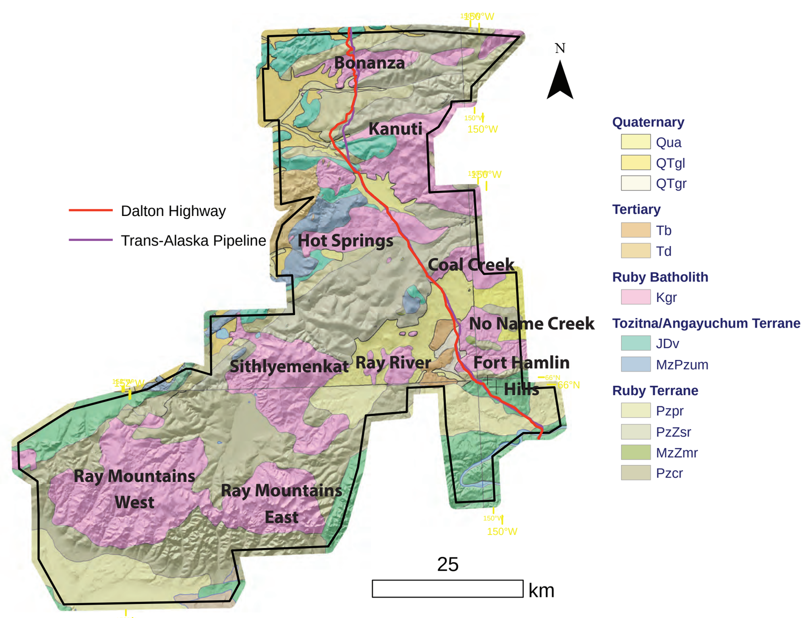
- There are hundreds of REE minerals you've never heard of!
- The common REE minerals in the Ruby Batholith:

Silicate	Phosphate	
Allanite	Monazite	Xenotime
$(Ce,Ca,Y,La)_2(Al,Fe^{2+},Fe^{3+})_3(SiO_4)_3(OH)$	$(Ce,La,Nd,Th)(P,Si)O_4$	$(Y,HREE)PO_4$

- Allanite and monazite have crystal lattice structures that favor the larger LREEs, while xenotime is dominated by the smaller HREYs.

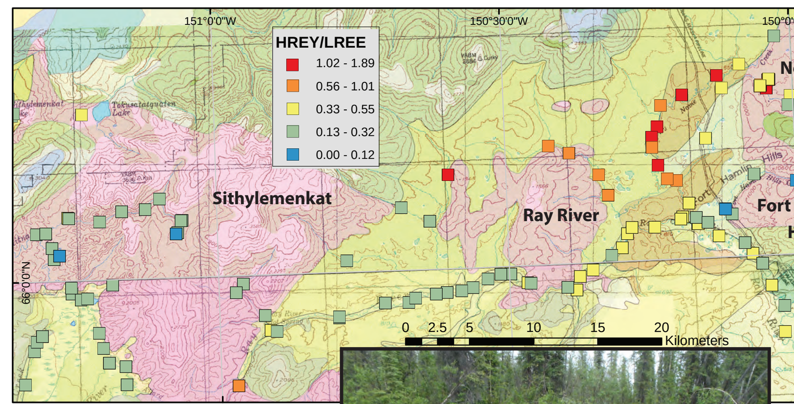
Study Area

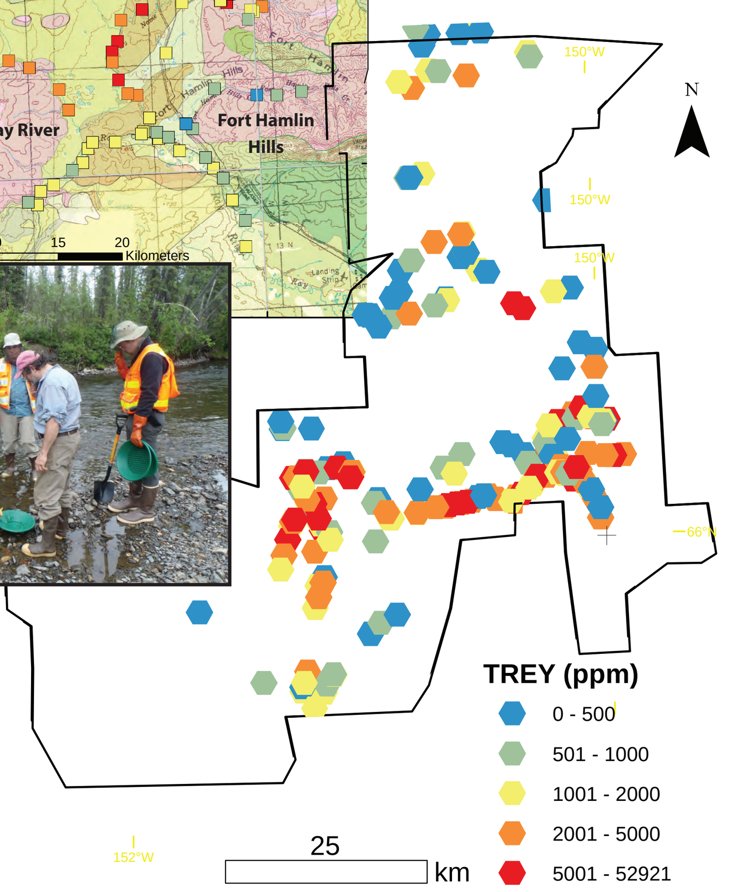




- The field area is located 125 miles NW of Fairbanks.

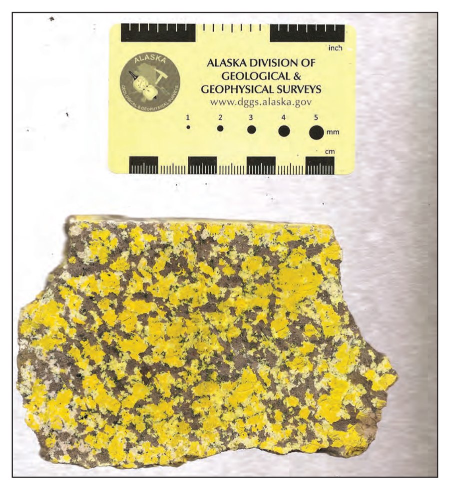
Panned Concetrates

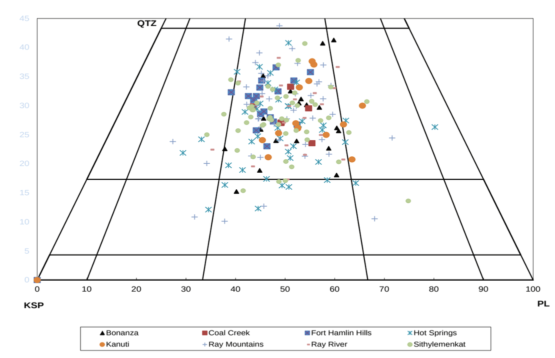




- The total rare-earth element (TREY) map to the right shows elevated concentrations (ppm) in the southern portion of the field area.
- The HREY/LREE map above shows only the southern plutons. The red squares indicate the highest relative HREY concentrations. These anomalous values were collected from Ray River and No Name Creek, draining plutons of the same names, respetively. Additionally, note that Fort Hamlin Hills appear to be draining material with low

Modal Composition



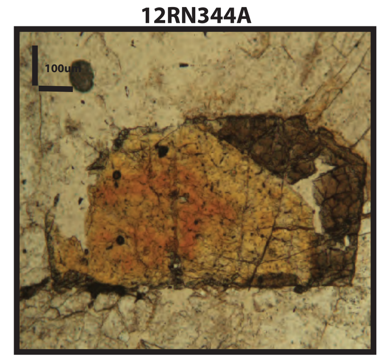


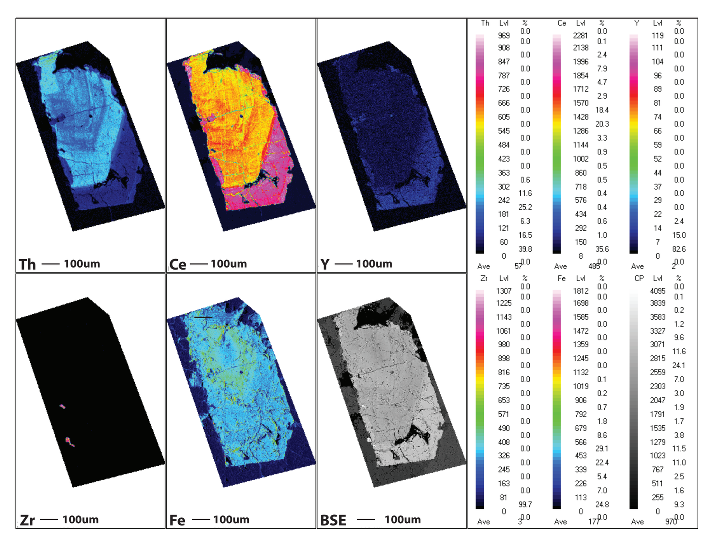
- Though there is a great deal of variation in trace elements, the major oxide compositions of the Ruby Batholith specimens plot uniformly as monzogranites.

Mineralogy

Petrography & Elemental Mapping

12RN344A

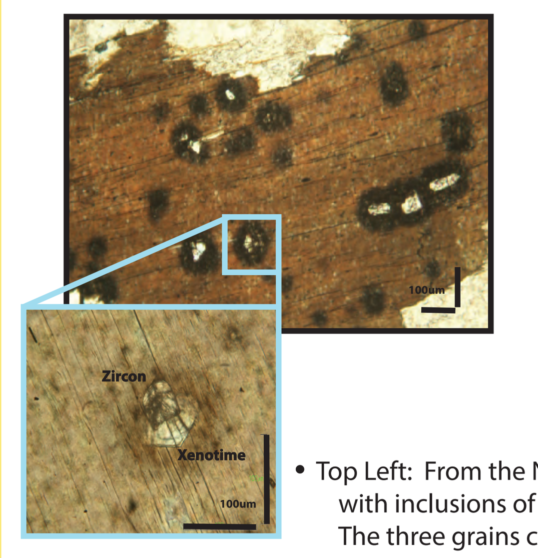


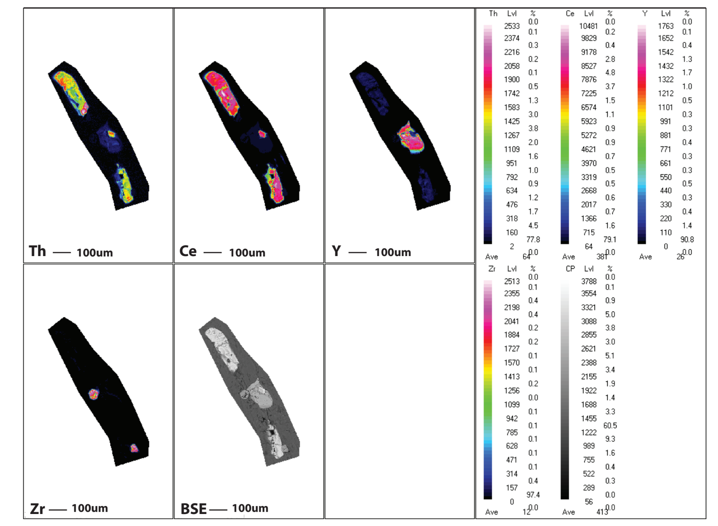


- Left: A photomicrograph of a single allanite crystal within sample 12RN344A from the Sithylemenkat pluton. Note the orange-brown zoning and elongate structure.
- Right: Elemental maps using EPMA WDS on the same allanite crystal. Note that the scales differ for each element. Elevated Th corresponds with the middle, light-hued zone shown in transmitted light. An enrichment of Ce is evident in the lighter portions as well.

Petrography & Elemental Mapping

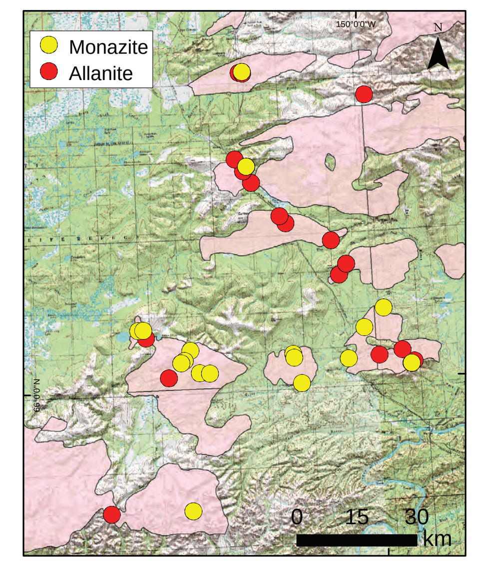
12RN319A





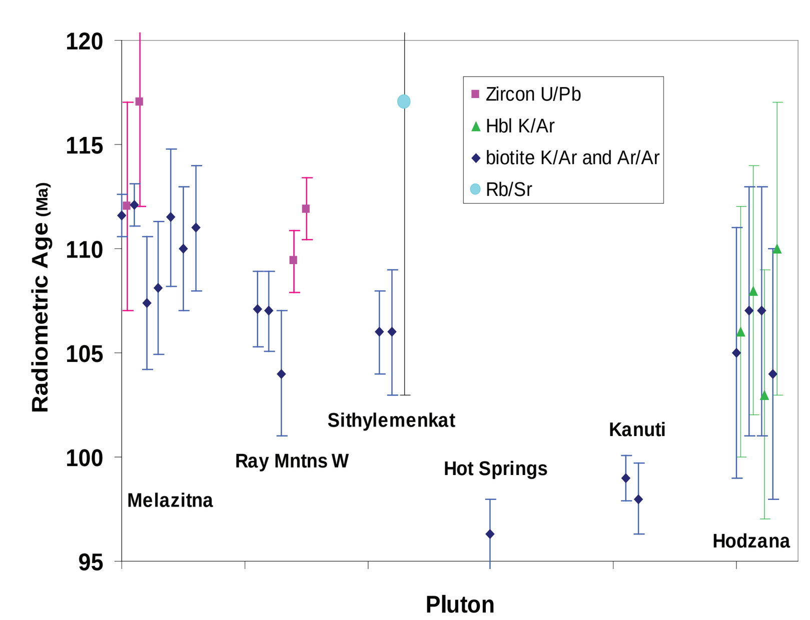
- Top Left: From the No Name Creek pluton, a photomicrograph of a biotite crystal with inclusions of (in order of likely abundance) zircon, monazite, and xenotime. The three grains clustered on the right are the same as those in the elemental map.
- Inset: The top-left crystal is zircon, the bottom-right is xenotime. Both crystals are tetragonal, so (as long as xenotime is being crystallized) it's common the find the HREY-beaing mineral in close association with zircon.
- Right: Elemental maps using EPMA WDS aid in identification (even of crystals we can't see!): The top and bottom grains are monazite, while the largest middle crystal is xenotime--with an inclsuion of monazite. Also in the middle of the cluster, as well as at the bottom, are zircons.

LREE Mineralogy



- The map to the left shows locations of samples with known allanite or monazite.
- Allanite is the typical REE mineral in the north, while monazite is more common in the south.
- Why the segregation?
  - Allanite is formed in high-Ca systems with a relatively high fO_2. It is also found with apatite and hornblende.
  - Monazite requires phosphorous, and is associated with xenotime.

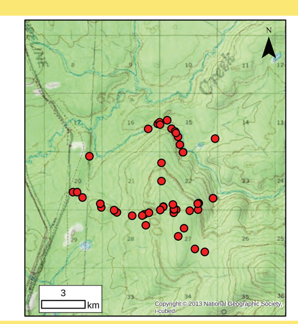
Radiometric Dating



- The Melozitna pluton is south of the study area. Meanwhile, the Hodzana pluton is north of the study area. It is included to dispute a potential N-S trend.
- The Hot Springs and Kanuti plutons are younger than the others. Though the sample locations were not adjacent to the known Tertiary volcanics, it is plausible that the ages were affected due to reheating.

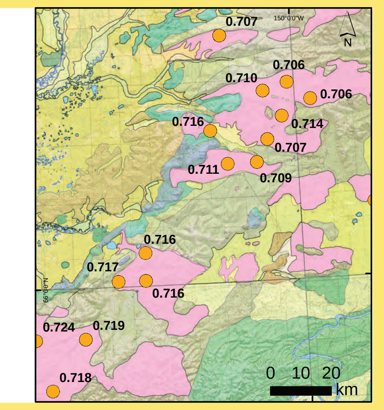
No Name Creek Pluton

- In the summer of 2013, additional field mapping and sample collection (red dots on map) were performed in the No Name Creek area, about ten miles north of the Yukon Bridge.
- The samples will undergo major-oxide and trace element analyses and geochronolgic (Ar-Ar and U-Pn), petrographic and microprobe studies.

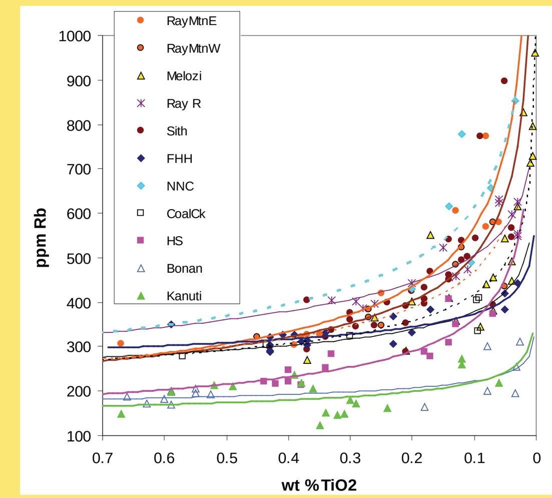


Initial Sr Isotopic Ratios

- The initial Sr isotopic ratios (SIR) are calculated from an age of 110 Ma.
  - SIR data taken from Arth et al. (1989)
- The SIR is the ratio of: of ^{87}Sr / ^{86}Sr.
- Minerals in different geologic settings have variable ratios.
- The initial SIR vary greatly in the Ruby Batholith because the starting material for each pluton appears to be different. Even within plutons, there appears to be a lack of homogeneity.
- SIR in the Ruby Batholith increase to the south.



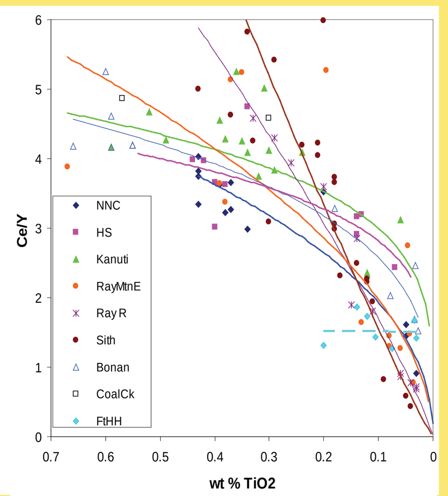
Fractionation Trends



LEFT: The plutons are divided into two categories when plotted back to an original Rb value. The northern plutons (Kanuti, Hot Springs, Bonanza) yeild initial Rb values of 180 ± 20. The remaining plutons plot an original Rb value of 300 ± 30. Yet within that range, Coal Creek and FHH behave as the northern plutons do, with Rb only incerasing slightly with fractionation.

RIGHT: All plutons* express an increase in HREY/LREE (with Y & Ce acting as proxies for such) with fracctionation, just at differing rates.

* Notice that No Name Creek has no apparent change in the ratio with fractionation and that all rocks have low Ce/Y ratios to start.



Conclusions

- REE Trends: REEs are more abundant in the southern half of the field area, and HREYs particularly are abundant in the southeast.
- The No Name Creek pluton is unlike any of the other nine: Elevated HREYs and the associated minerals, along with minimal fractionation.

Future Work

- Thorough petrographic investigations characterizing mineralogy and alteration.
- Construction of an EPMA WDS routine to analyze for monazite and its zoning.
- Ar-Ar and U-Pb dating on samples from No Name Creek, Ray River, Hot Springs and Kanuti plutons.
- Initial Sr isotopic compositions for the Bonanza, Coal Creek, Fort Hamlin Hills, Ray Mountains and Ray River plutons.
- Geochemical analyses and petrographic studies of the 2013 No Name Creek samples
- Compilation of an REE resource assessment report by the summer of 2014.

Acknowledgements

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This poster has been reviewed by Karri Sicard (karri.sicard@alaska.gov).

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