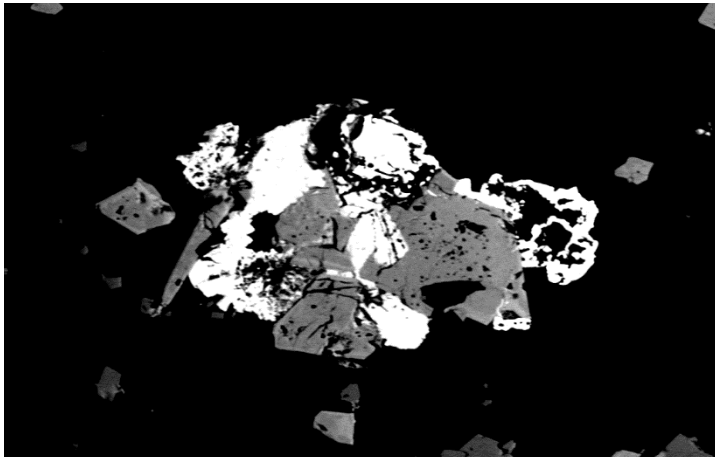
Textural Analysis, Mineral Chemistry and Rare-Earth Element Distribution in Mineralized Granitic Veins from the Eastern Cobequid Highlands, Nova Scotia.



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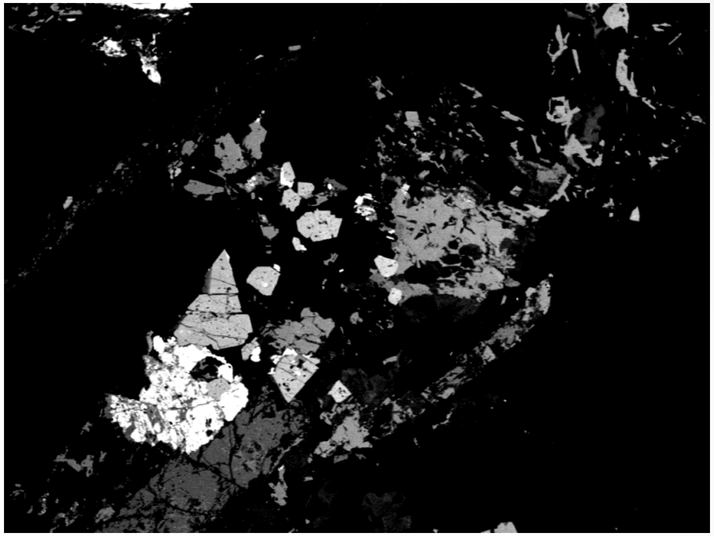
January the 29th 2013

The Reason for this Presentation

Donning his new canine decoder, Professor Schwartzman becomes the first human being on Earth to hear what barking dogs are actually saying.



To explain the results in the preliminary report and forth coming final report especially given the very technical nature of the study

Presentation Structure and Report Format

1. INTRODUCTION

1.1. Geological Setting

1.2. Comparison with some other North American REE deposits

1.3. Aim of this study

2. ANALYTICAL METHODS

2.1. Electron Microprobe Analyzer (EMPA)

2.2. BSE imaging and Textural analysis

2.3. Mineral (chemical) analysis

2.4. X-ray Mapping

3. RESULTS

3.1. Textural analysis

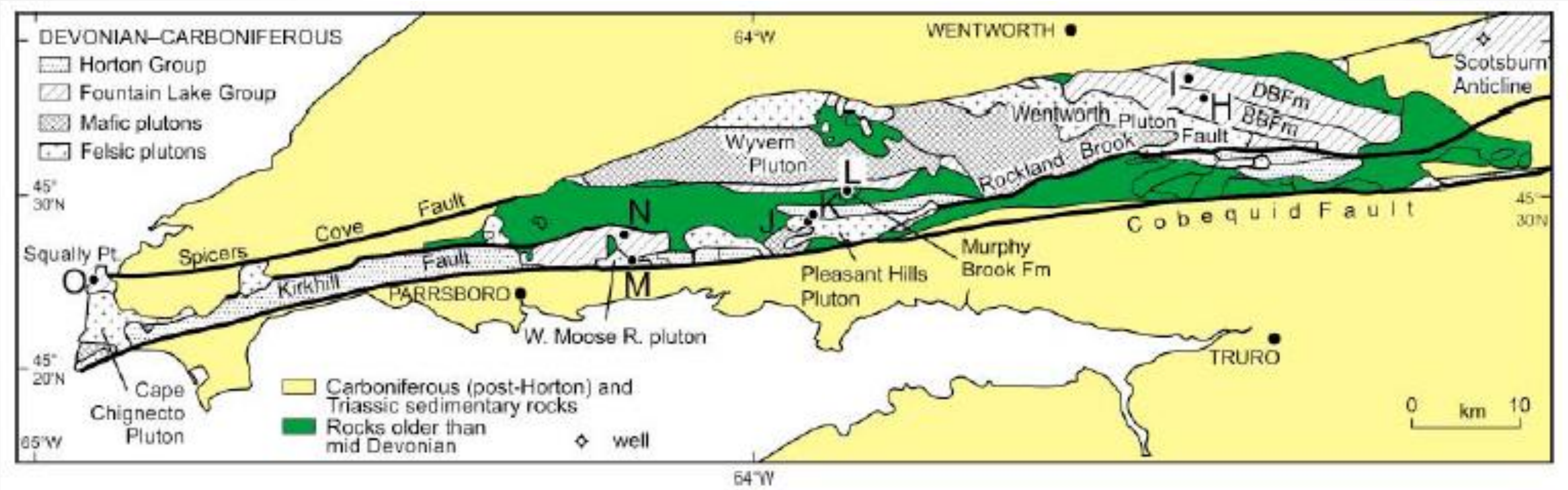
3.2. Mineral Analysis

3.3. REE distributions (mass balance) for one sample

4. CONCLUSIONS

1. Geological Setting

Per-alkaline granites and related rocks in the Cobequid Highlands

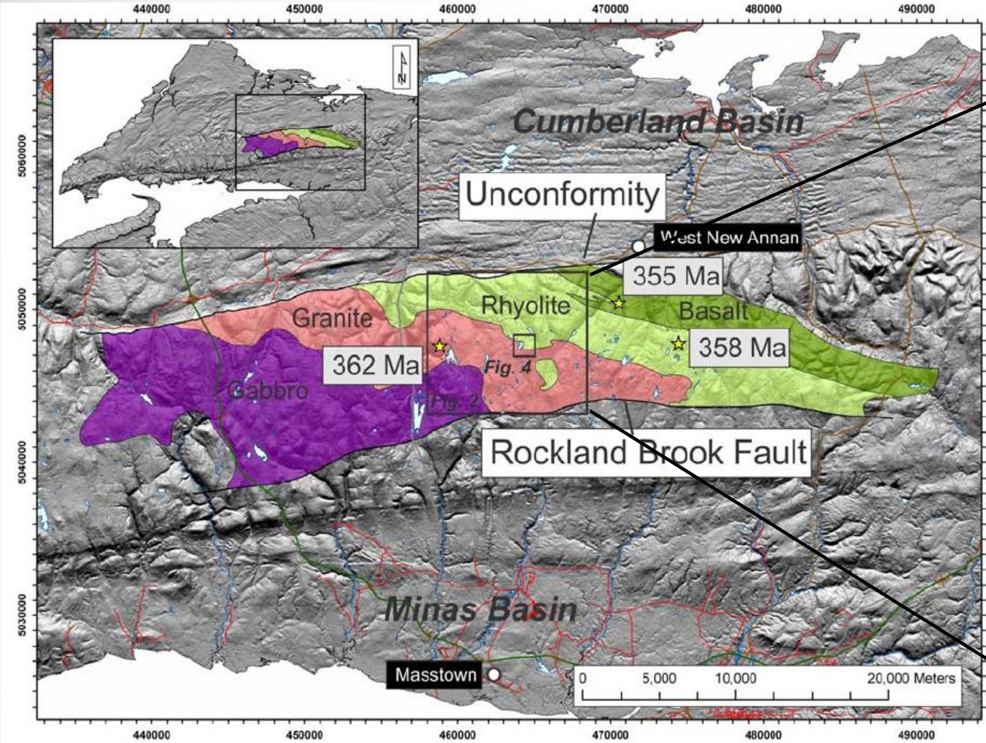


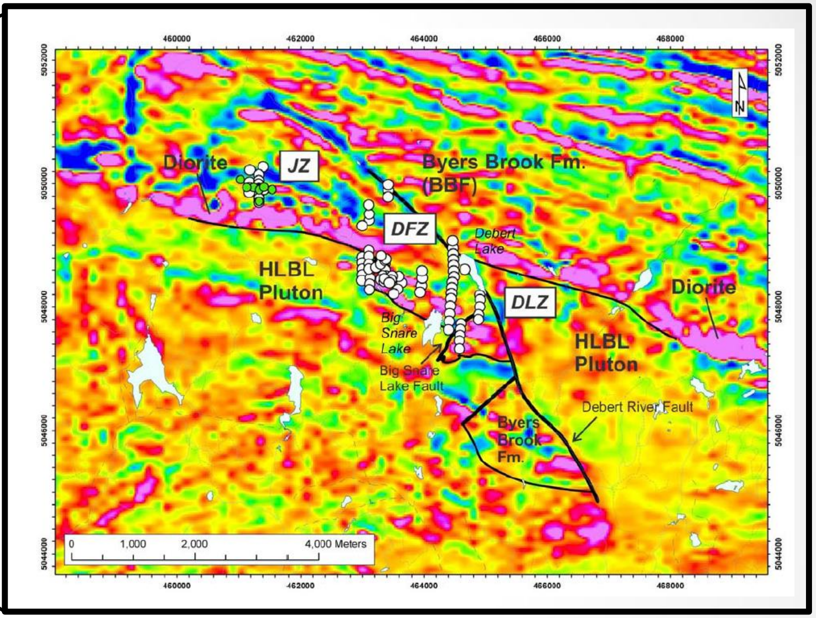
Map and U-Pb zircon ages from Dunning et al. (2002)

H = 358 +/- 1 Ma	Byres Brook Formation (BBF)
I = 355 +/- 3 Ma	Diamond Brook Formation (DBF)
J = 356 +/- 2 Ma	Granite Sill in the Pleasant Hills Pluton
K = 356 +/- 3 Ma	Granite Sill in the Horton Group
L = 360 +/- 2 Ma	Granite Sill in the Murphy Brook Formation
M = 361 +5/-3.5 Ma	West Moose River Pluton
N = 356 +/- 2 Ma	Fountain Lake Group
O = 355 +/- 2 Ma	Fountain Lake Group (Squally Point)

Geological Setting

Wentworth Pluton (HLBL Pluton)





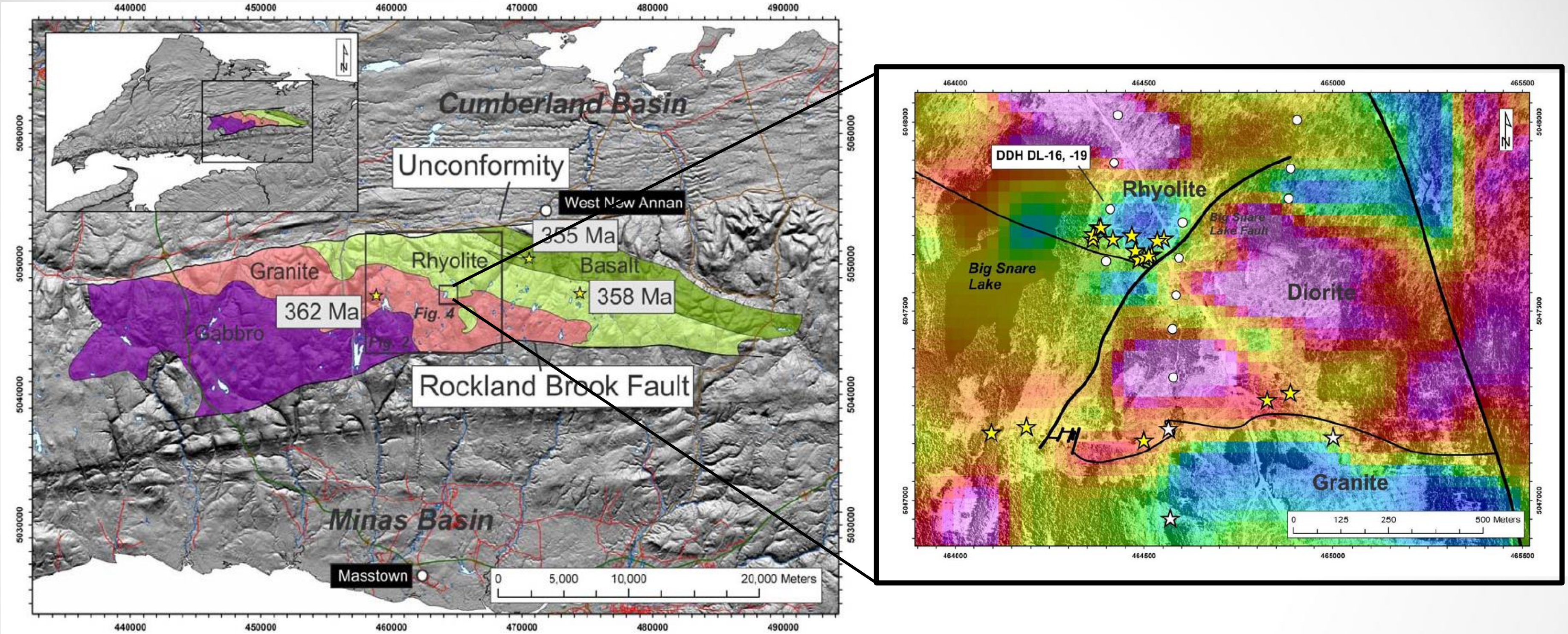
Maps from MacHattie (2010)

General Geology and magnetic gradient map of the Debert Lake area showing the contact between the Hart Lake – Byers Lake (HLBL) Pluton

volcanic activity -> intrusion of the plutons -> intrusion of mafic dykes -> later faulting

Geological Setting

Wentworth Pluton (HLBL Pluton)



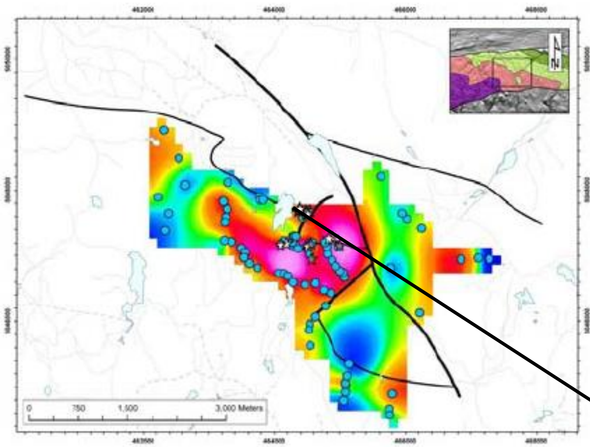
Maps from MacHattie (2010)

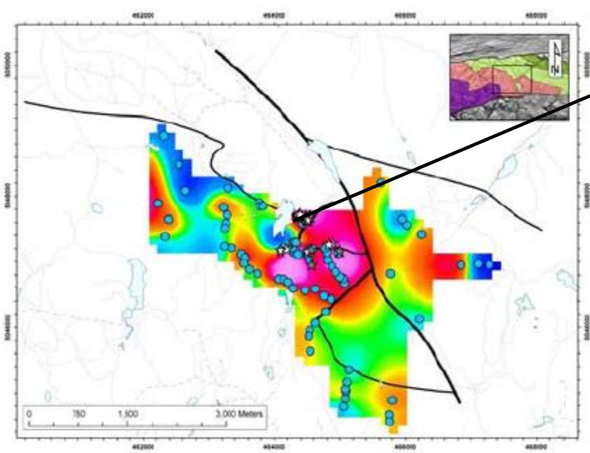
General Geology and vertical magnetic gradient map of the Big Snare Lake area showing the sample localities.

The samples were selected based on the geochemical maps (primarily Y concentrations) of MacHattie (2010) shown on the next slide

Geological Setting

Sample location





General Geology (inset) and geochemical maps showing concentrations of Y (top) and Zr (bottom).

Maps from MacHattie (2010)

Big Snare Lake

The samples were selected based on these geochemical maps (primarily Y concentrations) as well as the field relationships (next few slide) and geochemical analysis

Geological Setting

Sample Field Relations

Type 1 dyke cross-cutting the BBF rhyolite (sample 24)

REE dykes are younger than the BBF volcanics

Image from MacHattie (2010)

Geological Setting

Sample Field Relations

Image from MacHattie (2010)

A series of thin Type 1 dykes cross-cutting a late-stage of the HLBL Pluton

REE dykes are younger than the HLBL Pluton

Geological Setting

Sample Field Relations

Image from MacHattie (2010)

A branching Type 1 dyke cross-cutting a late-stage mafic dyke

REE dykes are younger than the late mafic dykes

Geological Setting

Sample Field Relations

Image from MacHattie (2010)

A Type 2 pegmatite / patch within a pegmatitic segment of the HLBL Pluton

REE pegmatites / patches are younger HLBL Pluton

The exact origin of these REE pegmatites / patches, and their relationship to the REE dykes is not fully understood

Geological Setting

Summary of the Geological History

1) Volcanic activity which produced the rocks of the Beaver Brook Formation (felsic volcanic and volcaniclastic rocks) followed by more mafic rocks of the Diamond Brook Formation. Ages suggest that this volcanic activity in the Debert Lake area occurred in a relatively short interval ~358-355 Ma (Dunning et al 2002).

2) Intrusion of HLBL Pluton. The available ages for plutonic rocks in the eastern Cobequid Highlands suggest older emplacement ages with a range of ~ 360-366 Ma (Doig et al. 1996; Dunning et al. 2002). A new investigation of the geochronology in the Debert Lake area (including the timing of mineralization) is currently being carried out (Broughm et al, in prep).

3) Emplacement of gabbro and diorite intrusions of the Folly Lake Pluton probably along with diabase dykes. This may have been contemporaneous with the basalts of the Diamond Brook Formation. The ages are as yet unconstrained.

4) Emplacement of the REE (HFSE) enriched dykes. The most significant clustering of these occurs east of Big Snare Lake. These dykes cross cut both the HLBL Pluton and BBL volcanic rocks as well as cross cut diabase dykes. It is from this area that the samples used in this study were collected (MacHattie 2011).

5) Tectonic deformation and uplift. The original super position and stratigraphy of the Cobequid Highlands suggests that is has been rotated ~90^{o} and exhumed between ~350-310 Ma to their current sub-vertical orientation.

Geological Setting

REE dykes in context

The emplacement of the REE (HFSE) enriched dykes is late in the geological history of the area.

The exact timing of this event is not known.

As you will see later, the emplacement (magmatic history) of these dykes was not the only factor in the REE mineralization.

We have ***later reworking*** of these rocks.

Could deformation be a factor?

Suggestion: Further work on the structural and field relationships of these dykes coupled with tarageet geochronology

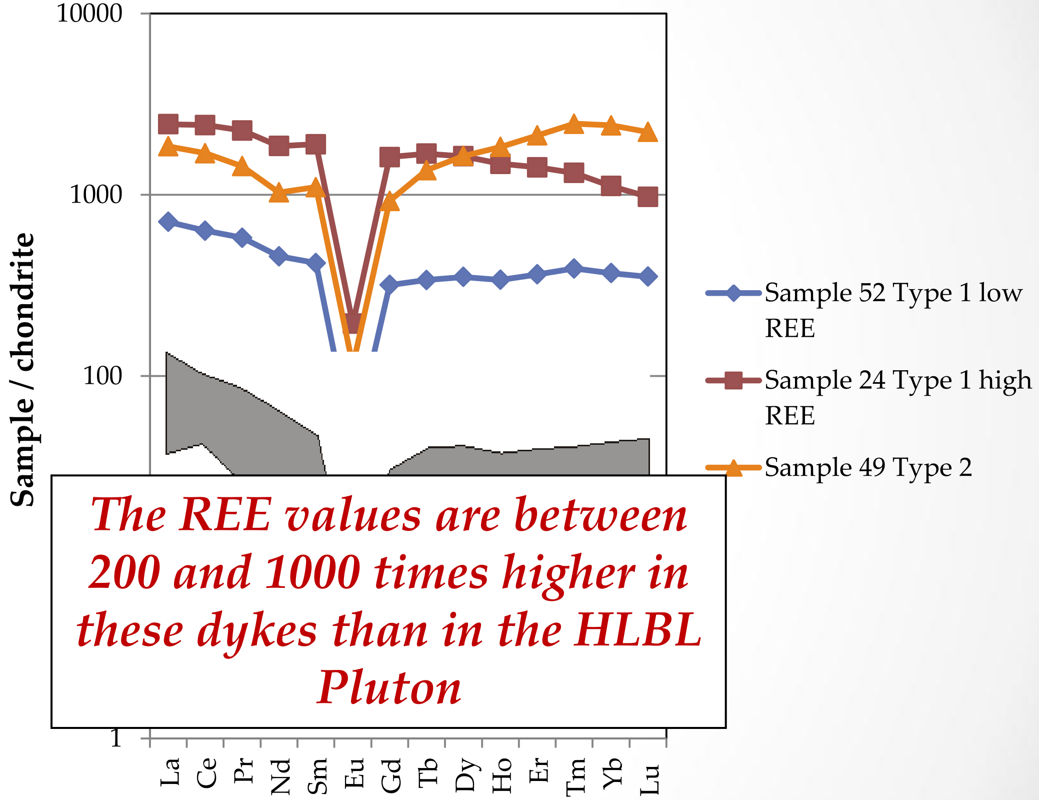
Samples

Samples selected for detailed analysis

Sample 52 Type 1 low REE
(non-mineralized)
(mineralized)

Sample 24 Type 1 high REE

Sample 47 Type 2

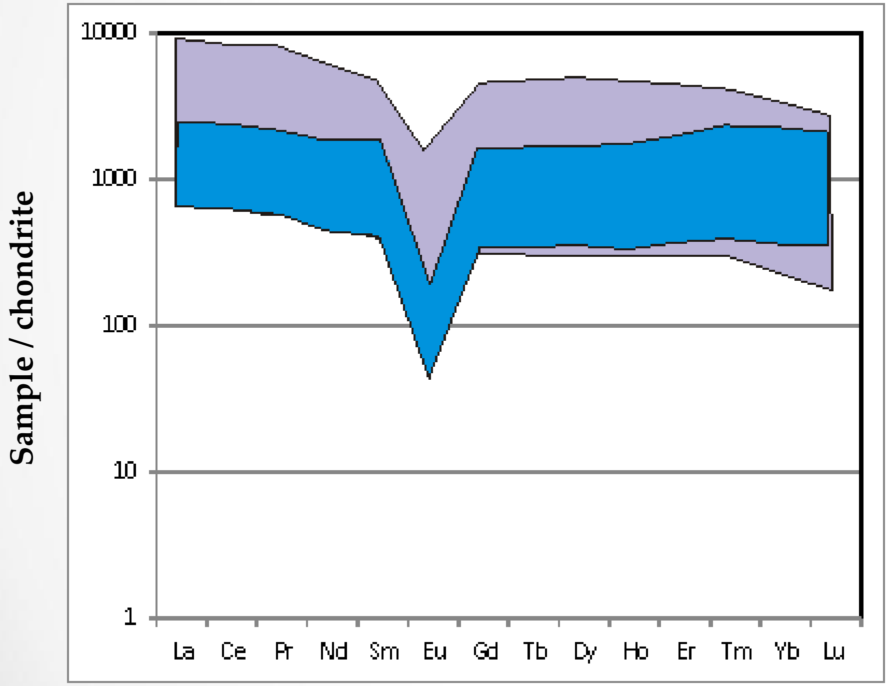


Chrondrite normalized REE values from the sample used in this study (data from MacHattie 2010)

Samples

A comparison with other North American REE deposits

Bokan, Alaska (Kendrick Bay)
Geoduck intersections



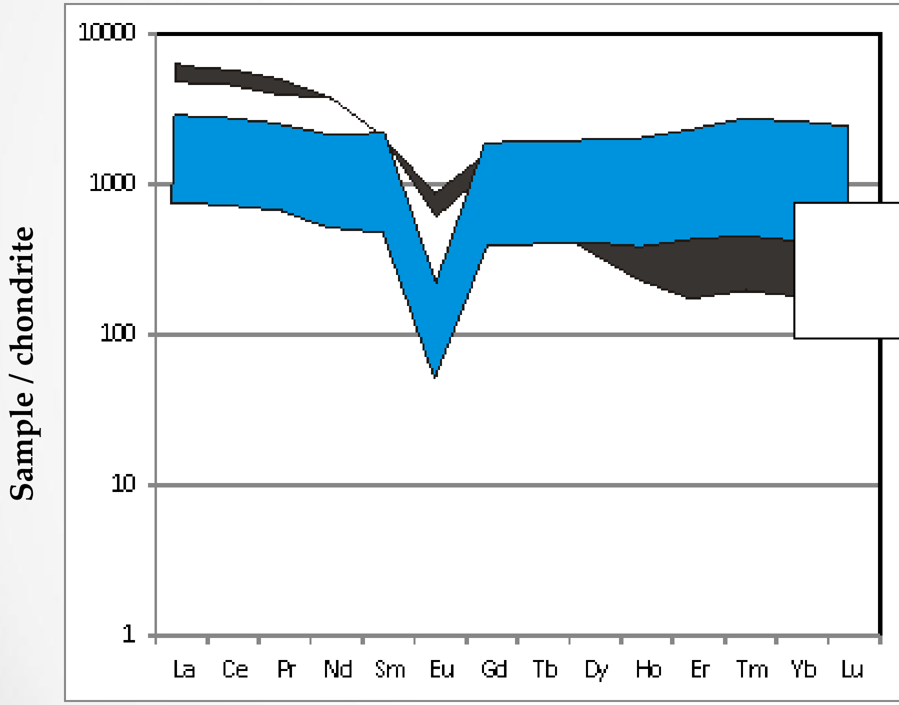
Data and images from Aurora Geosciences (Alaska) Ltd. for Ucore Rare Metals Inc. (Technical report, April 2011)

Comparible HREE concentrations and dyke / vein sizes

Samples

A comparison with other North American REE deposits

Thor Lake, NWT
Nechalacho (basal and lower)



Data from Avalon Rare Metals news release, January 2011. Images from Sheard et al. (2012).

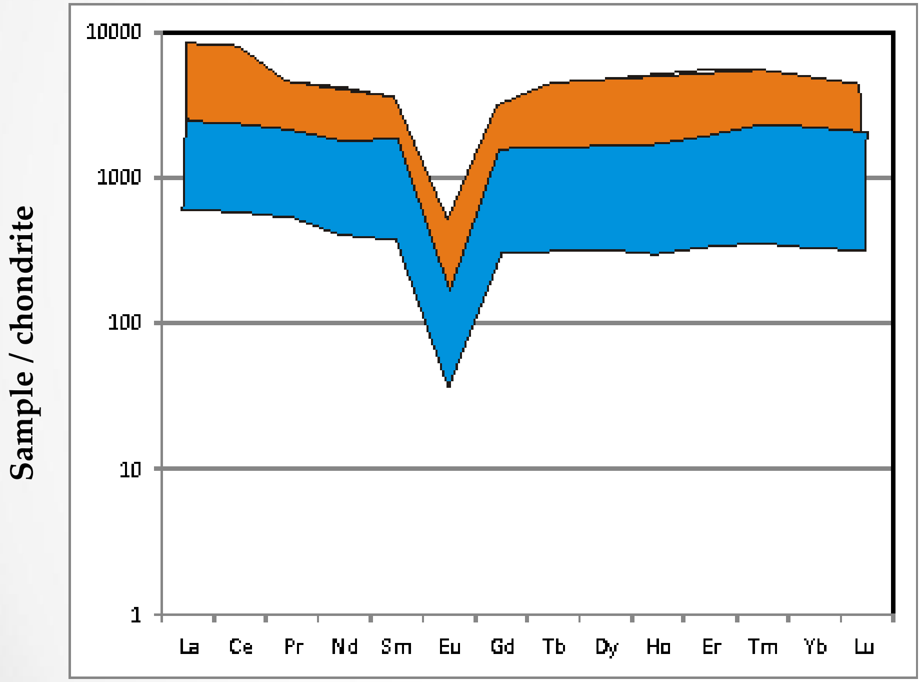
Secondary reactions to breakdown zircon

Somewhat higher HREE concentrations than Thor Lake. This is unusual give that Thor Lake is a rare zircon cumulate.

Samples

A comparison with other North American REE deposits

Strange Lake, Labrador



Similar HREE and similar textures to the Type 2 patches / dykes

Data and image from Kerr (2011)

Samples

REE dykes in context with other deposits

The Dykes from the Cobequid Highlands are very comparable in HREE contents to several of the known REE deposits.

The LREE's are generally lower but still highly enriched.

Y, Nb and Zr also show almost identical patterns (expect for Thor Lake).

Volumes (surface outcrops / intersections) are very similar to other deposits.

We have ***later reworking*** of all of these deposits.

Which minerals are present?

Analyze the samples for minerals and try to mass balance the REE

Aim of This Study

Mineral Characterization

Analyze the samples for REE bearing minerals and try to mass balance the REE contents.

Where are the REE and can they potentially be extracted?

Only Thor Lake has had a similar study to date (Sheard et al. 2012).

Electron Microprobe Laboratory at Dalhousie University

2. Analytical Methods

Electron Microprobe Analyzer (EMPA)

Electron Source (column) operating at ~15 kV

Wavelength Dispersive X-ray (WDX) detectors (5 in total)

Energy Dispersive X-ray (EDX) detector (1 in total)

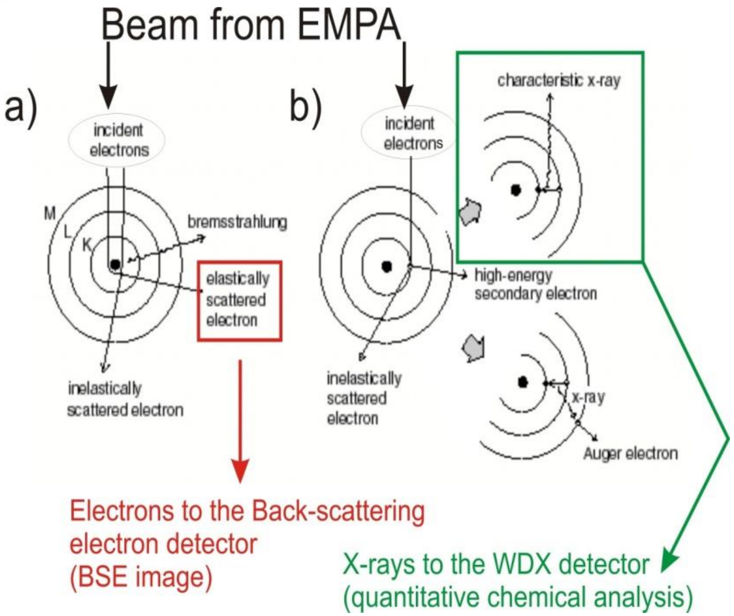
Back-scattering electron detector

Sample Chamber and Airlock

30 elements (all WDX), 12-14 mins per analysis, spot size was 1 μm, detection limits are around 50-400 ppm

Analytical Methods

Electron Microprobe Analyzer (EMPA)



a) Electron interaction with the atoms in the sample

b) The resulting effects of this interaction process

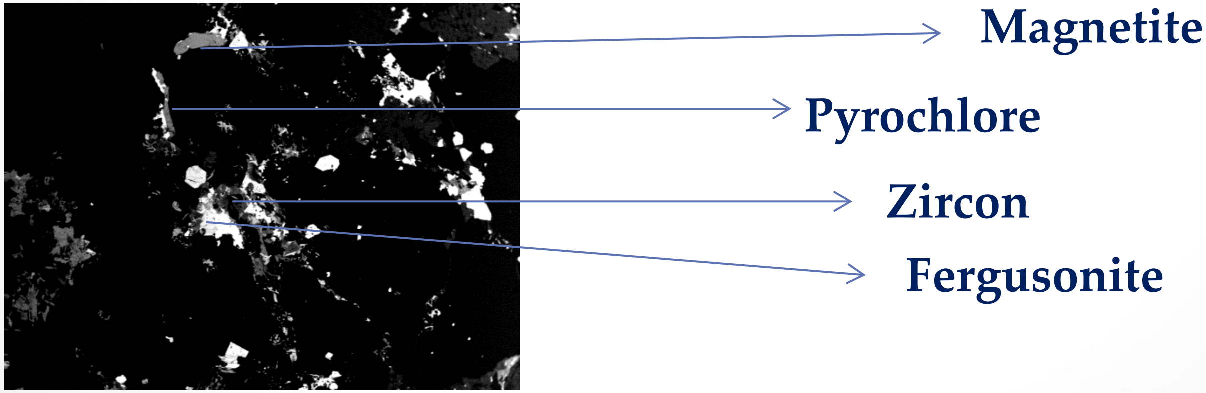
BSE images (mean atomic number) and chemical compositions (spot analysis and X-ray maps)

Analytical Methods

BSE images

Mineral	General Formula	Mean Atomic Number (pfu)	Typical Grain Size
Main phase minerals			
Na-amphibole	$Na_3(Fe^{2+})_4Fe^{3+}Si_8O_{22}(OH)_2$	14.15	>1 mm to several cm
K-feldspar	$KAlSi_3O_8$	11.84	>1 mm to several cm
Quartz	SiO_2	10.82	0.5 mm – 0.5 cm
Accessory minerals			
Magnetite	$Fe^{3+}{}_2Fe^{2+}O_4$	20.96	50-400 μm
Zircon	$ZrSiO_4$	22.02	150-300 μm
Fergusonite	$YNbO_4$	31.70	<50 μm

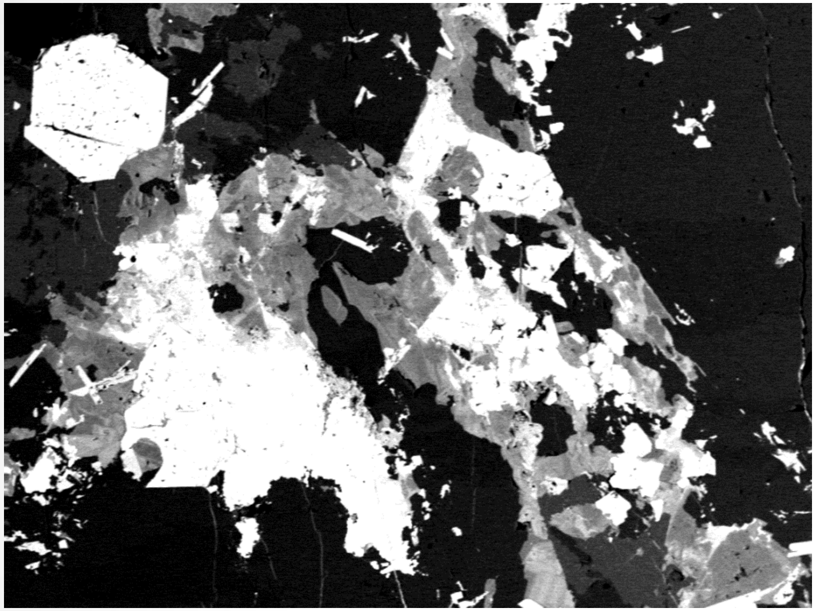
The higher the mean atomic number (Z-number) of the mineral the brighter the BSE image

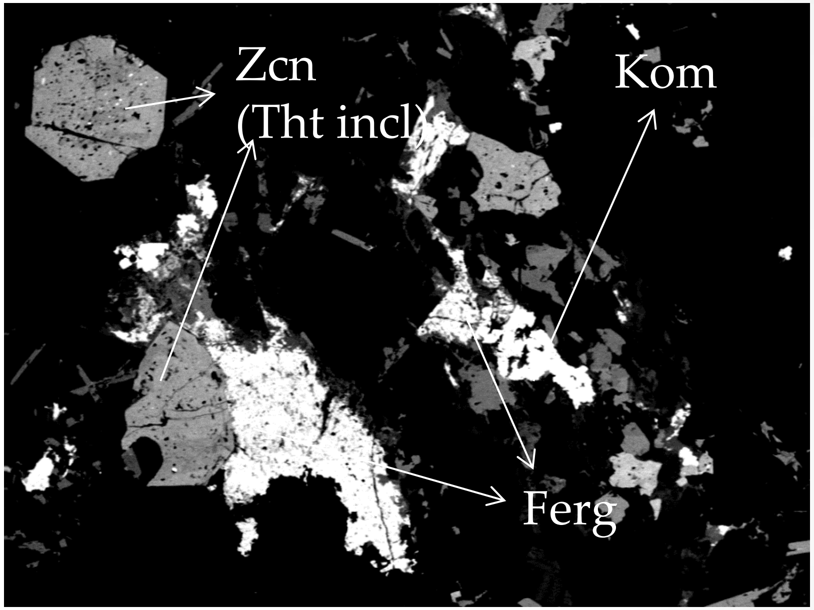


EDX detector is also used to initially confirm a mineral type (qualitative)

Analytical Methods

BSE images





The BSE detector gain is adjusted to proved different thresholds for the BSE images

These BSE images are used to give initial mineral distributions and textural information (grain sizes and shapes)

Run through a sample analysis

Sample 52 (low REE Type 1 dyke)

The Type 1 dykes are the most extensive in outcrop

Sample 52 shows two textural settings so is idea for demonstrating the methods

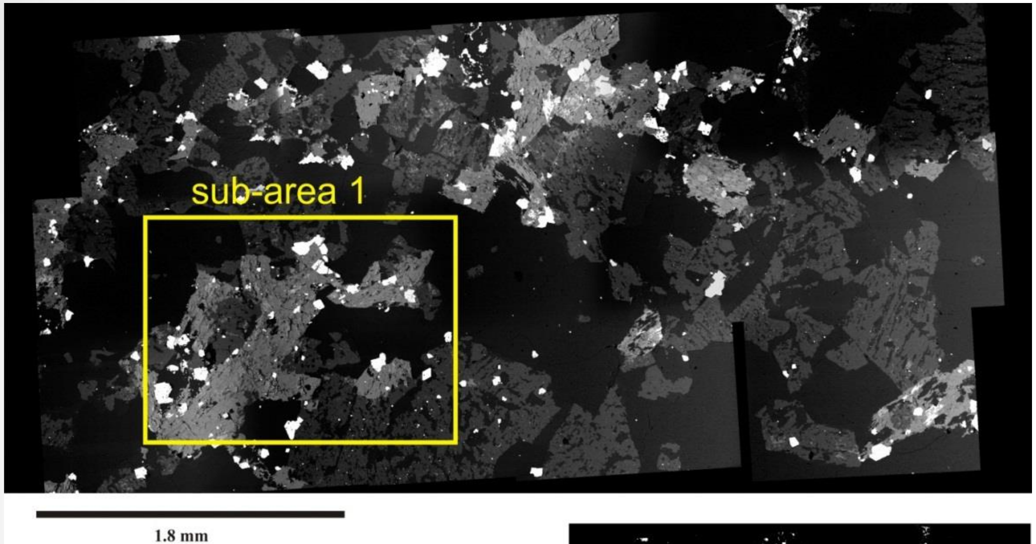
Sample 52 is enriched in REE-Nb-Y but also contains lots of zircon

If this sample shows promise as a REE deposit then clearly the other samples will only show more potential

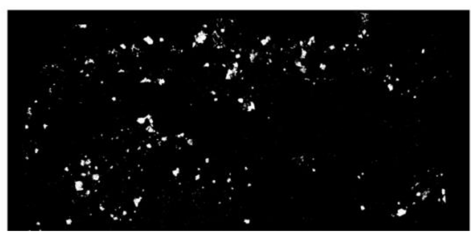
1) **Textural analysis**
2) **Mineral analysis**
3) **Mass balance**
4) **X-ray mapping**

Textural Analysis

Sample 52 (low REE Dyke)



Sample 10TM0052 (area 1)
non-mineralized segment



1) Collect a series of BSE images from a large area

2) Carry out an image analysis from this whole area

The result of this first analysis give an idea of how much mineralization is present

Textural Analysis

Sample 52 (low REE Dyke)

Particle Size Range	Total Particles	% Area of Sample	Average Particle Size (μm^2)
unlimited	1491	2.223	659.99
>500 μm^2	227	2.053	4003.95
250-500 μm^2	71	0.059	365.22
100-250 μm^2	152	0.055	160.55
50-100 μm^2	150	0.023	69.34
10-50 μm^2	462	0.026	25.15
<10 μm^2	429	0.006	6.49

Total of high Z-number minerals (bright in BSE) = 2.223% of this area

This represents 1491 particles (apparent mineral grains) in total

This includes all the REE-minerals, zircon, oxides, etc.

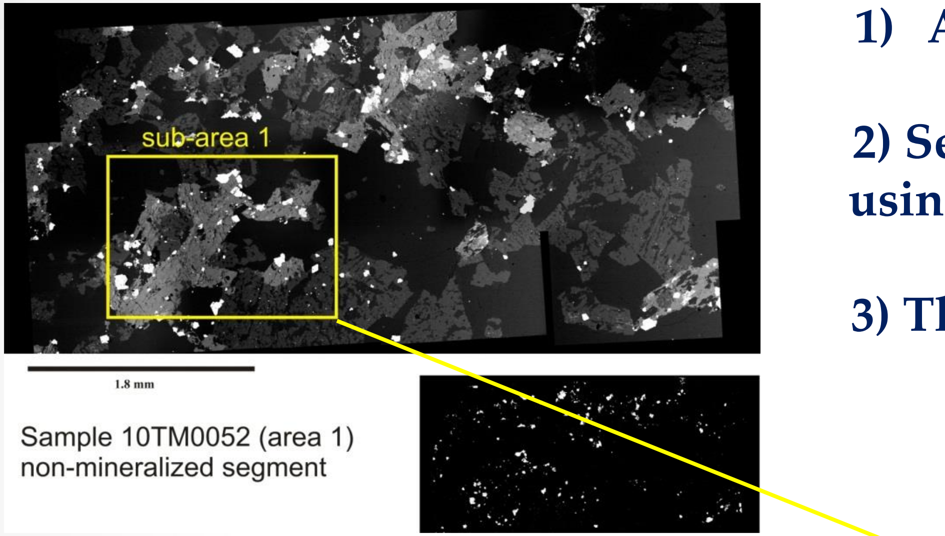
It does not include main-phase minerals

In other words this is the maximum possible % of minerals which may be economically valuable at least in terms of REE's

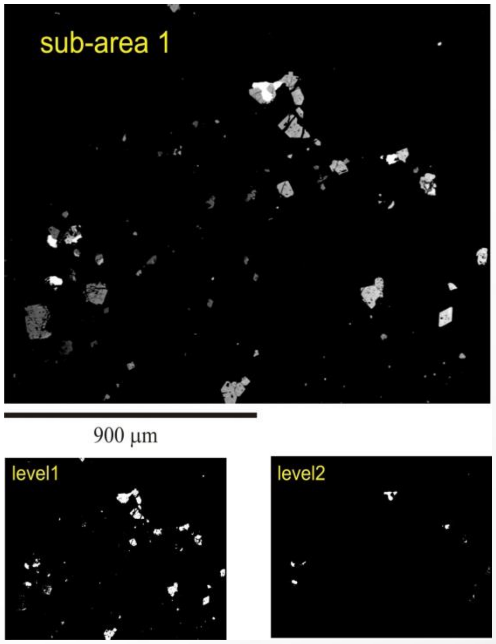
The rest of the table shows the relative grain sizes of this 2.223%

Second Stage of Textural Analysis

Sample 52 (low REE Dyke)



1) A sub-area is chosen for further analysis
2) Several BSE images are collected using different thresholds (detector gain settings)
3) This helps "screen out" different mineral phases



This is done to determine more accurately what % of REE minerals are present

Second Stage of Textural Analysis

Sample 52 (low REE Dyke)

Particle Size Range	Total Particles	% Area of Sample	Average Particle Size (μm^2)
Threshold level 1(all accessory minerals)			
unlimited	172	1.941	277.45
>500 μm^2	20	1.629	2002.79
250-500 μm^2	8	0.098	301.31
100-250 μm^2	18	0.116	158.41
50-100 μm^2	15	0.042	68.78
10-50 μm^2	43	0.042	23.99
<10 μm^2	68	0.014	5.01
Threshold level 2 (highest mean atomic number minerals)			
unlimited	41	0.272	163.26
>500 μm^2	5	0.229	1124.27
250-500 μm^2	1	0.012	300.14
100-250 μm^2	2	0.013	159.32
50-100 μm^2	2	0.005	59.40
10-50 μm^2	13	0.011	19.96
<10 μm^2	18	0.003	4.52

1) **The images are analyzed the same way**

2) **The result is to show the “true” percentage of the highest Z-number minerals**

3) **These are almost exclusively the REE-bearing phases**

When this is done over several such areas an accurate % of REE minerals is established →

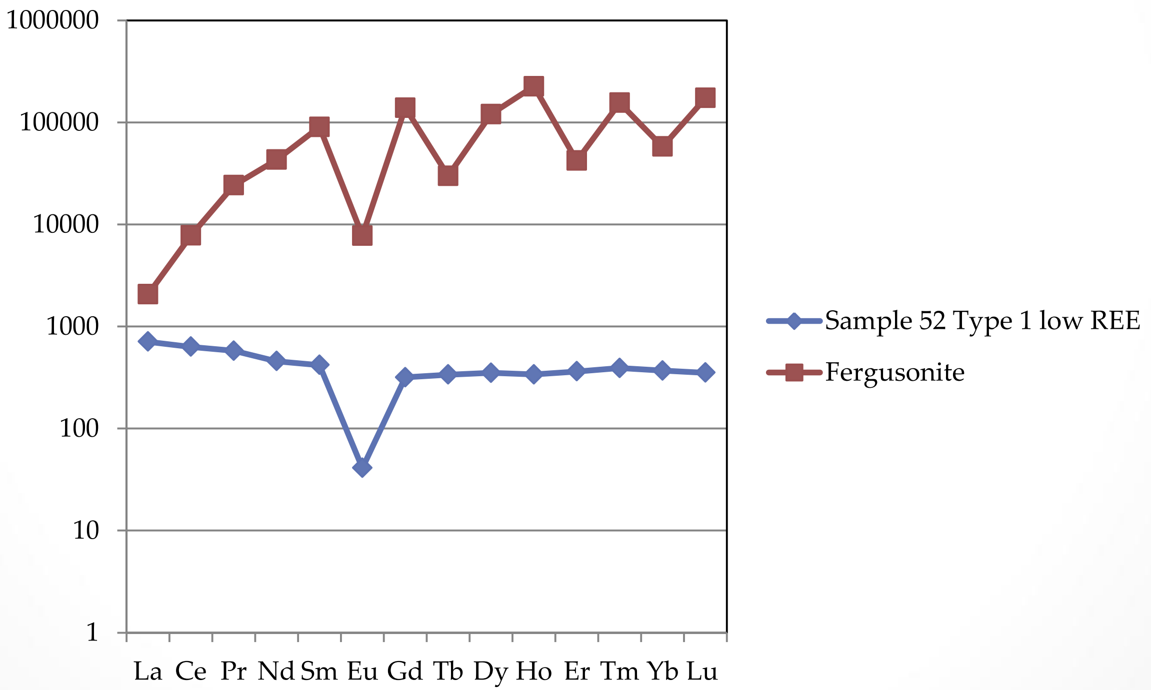
These minerals are then analyzed for all 30 elements by WDX

Mineral Analysis

Sample 52 (low REE Dyke)

1) The minerals are analyzed for 12-14 mins for 30 elements

2) The results show the percentage of elements (REE included) in these highest Z-number minerals



When combined with the textural analysis this tells us how much of the total REE's from the whole rock are in the Fergusonite

Mass Balance

Sample 52 (low REE Dyke)

1) Sample area = 0.0324 cm^2

2) 2.7 gm/cm^3 rock density

3) Area mass = 2.7 * 0.0324 = 0.0875 gm

4) Fergusonite = 0.227% of this volume

5) Fergusonite = 0.0002 gm in this area

6) So in one cm^3 of rock there will be 0.00054 gm of Fergusonite

7) One m3 of rock (2.7 tons) = 1,000,000 * 0.00054 gm
= 540 gm of Fergusonite

Or Fergusonite = 540 / 2.7 = ~200 gm / ton

Mass Balance (cont.)

Sample 52 (low REE Dyke)

1) **In this area the Fergusonite controls the most of the Heavy REE budget**

2) **Other mineral present in this area of the sample includes allanite (Ce and La)**

	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Fergusonite	562.8	11840.2	3836.9	37270.7	20321.4	2610.5	38736.0	2736.9	41401.3	17277.0	11357.9	5455.3	14983.3	5839.2
(REE ppm)	332.6	5804.9	2264.5	25440.2	20105.5	760.7	42651.3	2597.9	45954.9	19546.8	12231.6	6164.6	15668.8	6692.2
	759.0	7443.9	3315.6	30649.8	20848.2	674.2	42512.4	1737.7	45954.9	19180.2	10484.2	5604.1	14341.8	6586.7
Average	551.5	8363.0	3139.0	31120.2	20425.0	1348.5	41299.9	2357.5	44437.0	18668.0	11357.9	5741.3	14998.0	6372.7
Whole Rock	260.0	606.0	79.2	325.0	96.9	3.6	97.1	19.6	134.0	28.8	90.4	14.1	91.5	13.4
Proportion in Fergusonite	1.5	22.7	8.5	84.6	55.6	3.7	112.3	6.4	120.9	50.8	30.9	15.6	40.8	17.3
% in Fergusonite	0.6	3.8	10.8	26.0	57.3	102.7	115.7	32.7	90.2	176.3	34.2	110.8	44.6	129.4

The REE enrichment by Fergusonite in some cases is overestimated but in fact this does not change the fact that this mineral dominates the many of the Heavy REE in this sample

Value?

Sample 52 (low REE Dyke)

1) Dysprosium metal is currently ~$1,100 kg (21st of December)
2) At least 90% of the Dy is in Fergusonite
3) 200 gm/ton of Fergusonite
4) 4.4% Dy in Fergusonite
5) 0.044 * 0.2 * 1100 = $9.89 per ton of ONLY Dy in Fergusonite

Other ore minerals identified include
Bastnäsite, Chevkinite, Komarovite, Samarskite, Pyrochlore and other unnamed Light REE-rich phases (Ce, La, Pr, etc.)

Rest of the REE + Y

Sample 52 (low REE Dyke)

1) **Expand the calculation to the other REE + Y**

2) **TRE + Y value of Fergusonite “ore” = $18.75 / ton**

	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Y
Average (ppm)	551.45	8363.01	3139.03	31120.24	20425.00	1348.47	41299.93	2357.49	44437.02	18667.99	11357.89	5741.33	14997.98	6372.70	157520.00
Average %	0.06	0.84	0.31	3.11	2.04	0.13	4.13	0.24	4.44	1.87	1.14	0.57	1.50	0.64	15.75
$ per Kg	28.00	25.00	120.00	115.00	55.00	2150.00	210.00	2500.00	1100.00		275.00				120.00
Value / ton	0.00	0.04	0.08	0.72	0.22	0.58	1.73	1.18	9.78	0.00	0.62	0.00	0.00	0.00	3.78

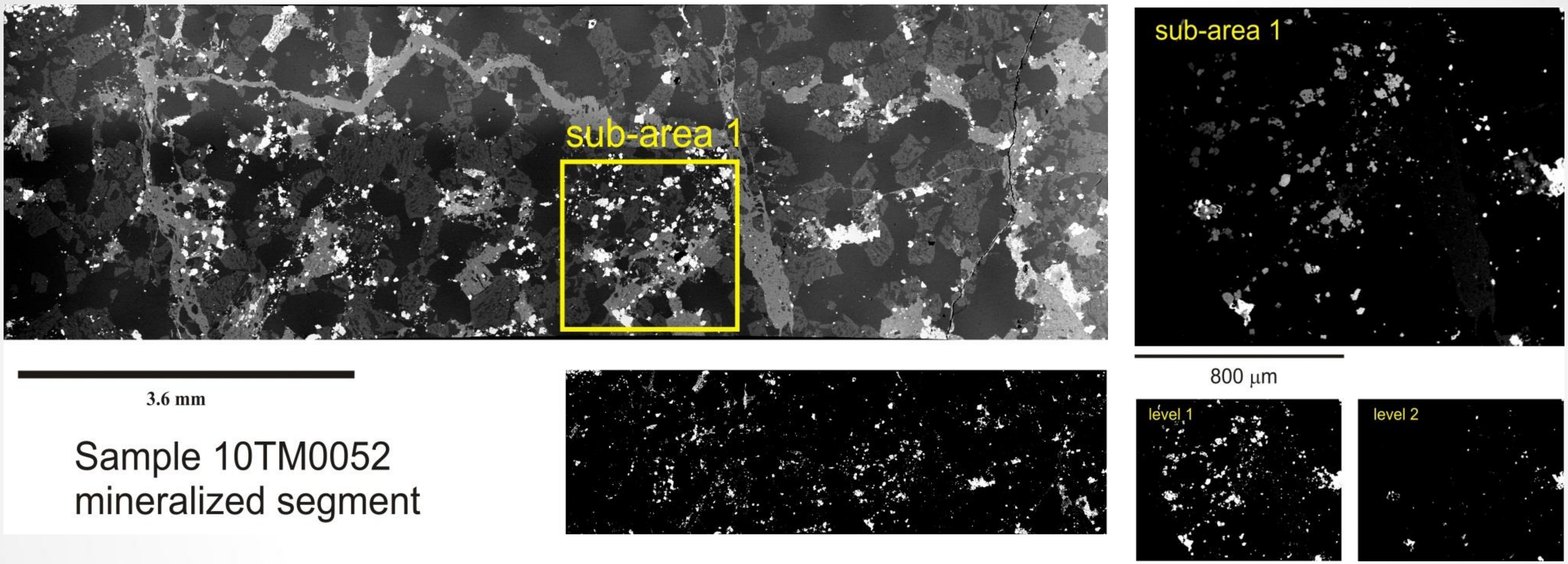
Remember **this is the least mineralized section of the lowest REE bearing sample**

Only based on 1 of the REE-minerals present

Other ore minerals identified include the Light REE’s (Ce, La, Pr, etc.) which are easy to liberate

Textural Analysis

Sample 52 (low REE Dyke)



1) Mineralized area (epidote veins) – enhanced REE redistribution

Strong association with secondary veins and mineralization – loss of amphiboles

Textural Analysis

Sample 52 (low REE Dyke – mineralized area)

Particle Size Range	Total Particles	% Area of Sample	Average Particle Size (μm^2)
unlimited	5874	4.588	354.55
>500 μm^2	621	3.856	2805.48
250-500 μm^2	359	0.288	363.27
100-250 μm^2	600	0.214	161.24
50-100 μm^2	625	0.102	73.56
10-50 μm^2	2037	0.108	24.05
<10 μm^2	1605	0.020	5.67
Particle Size Range	Total Particles	% Area of Sample	Average Particle Size (μm^2)
Threshold level 1(all accessory minerals)			
unlimited	637	5.185	156.28
>500 μm^2	41	3.418	1600.43
250-500 μm^2	43	0.787	351.45
100-250 μm^2	55	0.444	154.96
50-100 μm^2	59	0.222	72.08
10-50 μm^2	187	0.246	25.24
<10 μm^2	252	0.069	5.26
Threshold level 2 (highest mean atomic number minerals)			
unlimited	139	0.897	31.17
>500 μm^2	2	0.445	1073.79
250-500 μm^2	1	0.058	278.73
100-250 μm^2	1	0.025	118.49
50-100 μm^2	10	0.150	72.20
10-50 μm^2	31	0.162	25.27
<10 μm^2	94	0.058	3.00

Total of high Z-number minerals (bright in BSE) = 4.588% of this area (2.223%)

This represents 5874 particles (1491 in area 1)

The accessory phases including Fergusonite = 0.897 % (versus 0.272%)

In other words this secondary process = 2 – 5 times the mineralization

Conclusions

Magnum Deposit and REE minerals

1) Even a simple comparison shows several similarities with many of North America's major REE deposits

2) Secondary processes have liberated the REE into phases such as Fergusonite which are recoverable

3) Already an estimated value $18.75 per ton of rock for ***ONLY*** Fergusonite in the lowest REE mineralized sample. This value can only increase significantly as other analysis are finalized.

4) More mineralized section have 2 to 5 times this value.

5) Textures, reactions and HREE-minerals of these rocks are very similar to Bokan, Alaska.

Bokan has had over $7 million in development investment in the drilling program alone