GEOCHEMICAL ANALYSIS OF BEAVER RIVER DIABASE IN COMPARISON TO ANORTHOSITE INCLUSIONS AND SIMILAR MID- CONTINENTAL RIFT DIABASE

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BACKGROUND MID- CONTINENT RIFT SYSTEM

- Also known as Keweenawan Rift
- Middle Proterozoic in age: ~ 1.1 Ga
- Triple- junction rift that extends into Kansas and the lower peninsula of Michigan
- Outcrops from the MRS are only seen around the Lake Superior region
- Generally composed of flood basalts and intrusions
- Source was a mantle plume
- End of MRS could be Grenvillian orogeny (debatable)

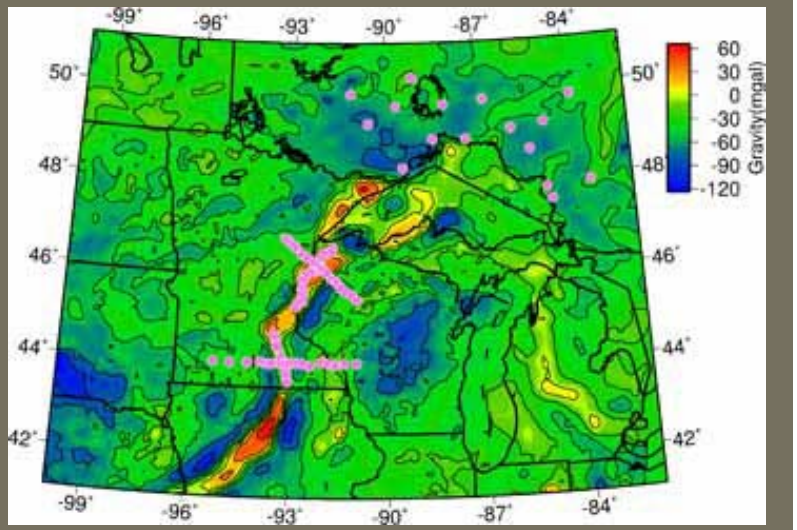
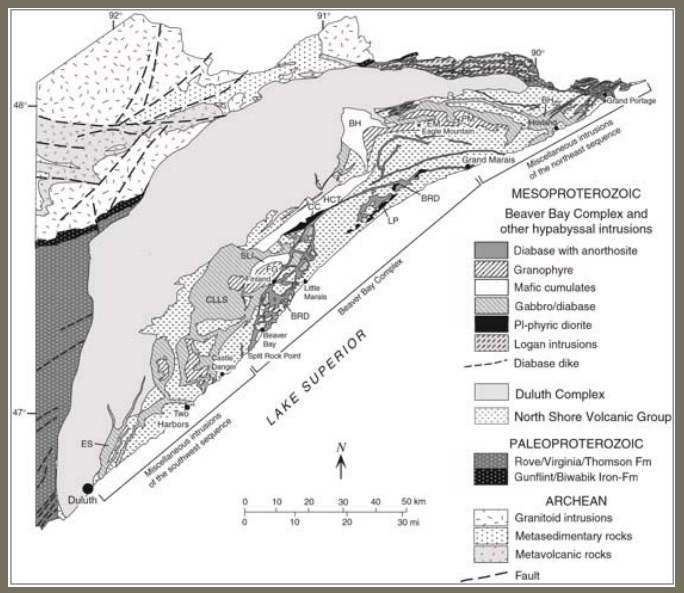


Image: www.earthscope.org
Miller (1997)

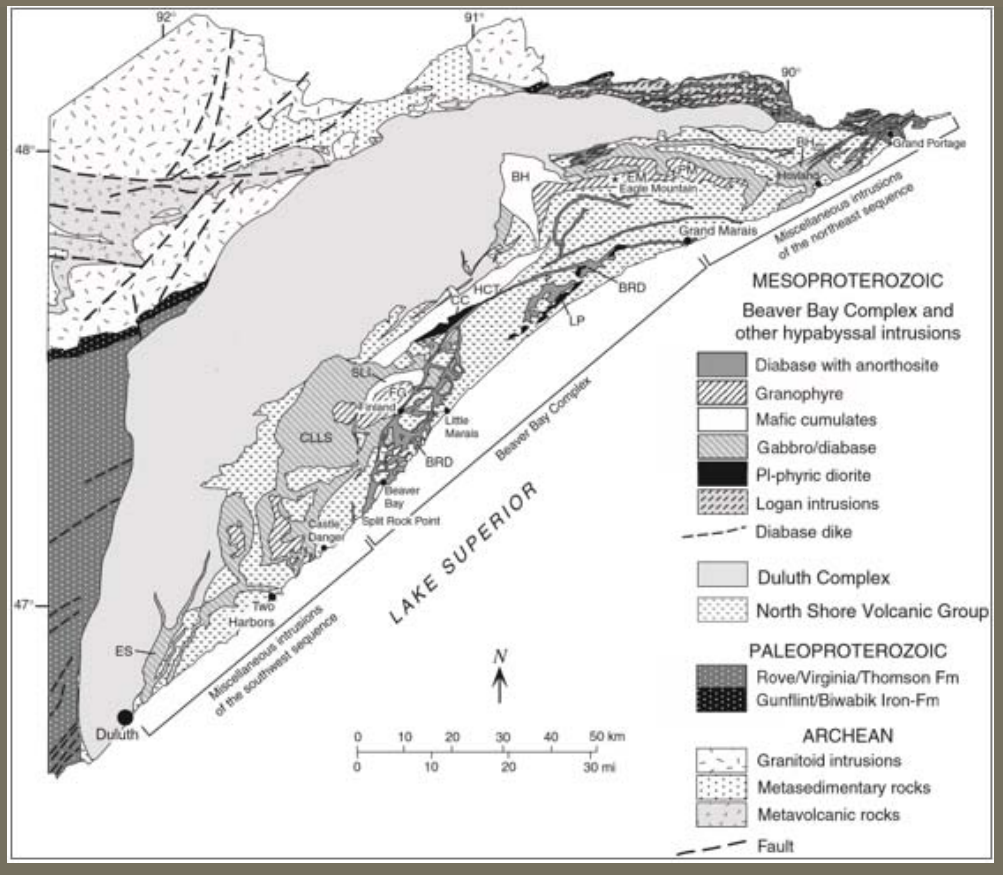
LAKE SUPERIOR REGION

- Many intrusions in comparison to volcanic rock (60%)
- Types of intrusions: Troctolitic, gabbroic, anorthositic, and granitic
- Duluth Complex, North Shore Volcanic Group, and Hypabyssal Intrusions
- Most hypabyssal intrusions are younger than Duluth Complex
- Transitional boundary between complexes
- Faults



Green (1972)
Miller (1997)
Map: Miller and Green (2002)

LAKE SUPERIOR REGION



Map: Miller and Green (2002)

HYPABYSSAL INTRUSIONS

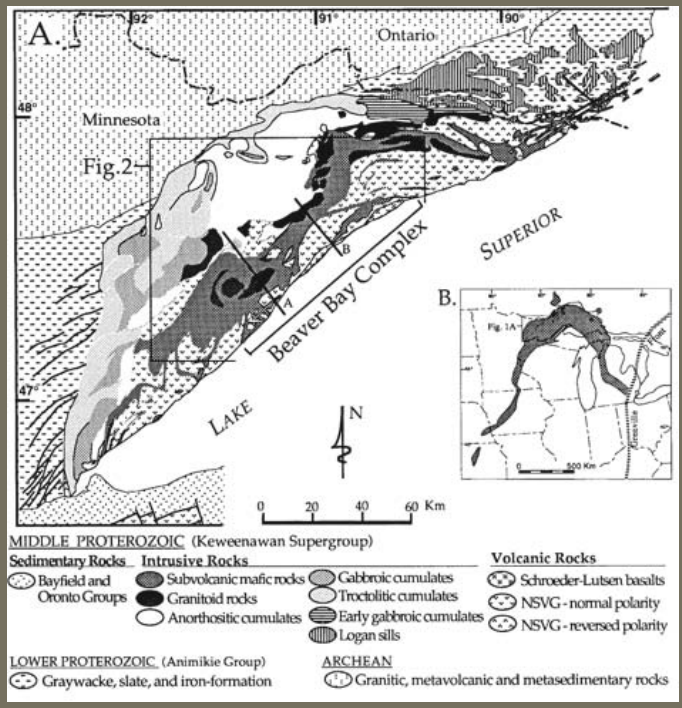
- Definition: a sub-volcanic rock; an intrusive igneous rock that is emplaced at medium to shallow depth within the crust between volcanic and plutonic
- Largest concentration of these subvolcanic intrusions forms the Beaver Bay Complex
- Whole rock compositions approximate the magma compositions
- Most hypabyssal intrusions do not display igneous foliation and lack signs of differentiation
    - But late intrusions do! Ex. Sonju Lake, Beaver River Diabase

Miller and Green (2002)

BEAVER BAY COMPLEX

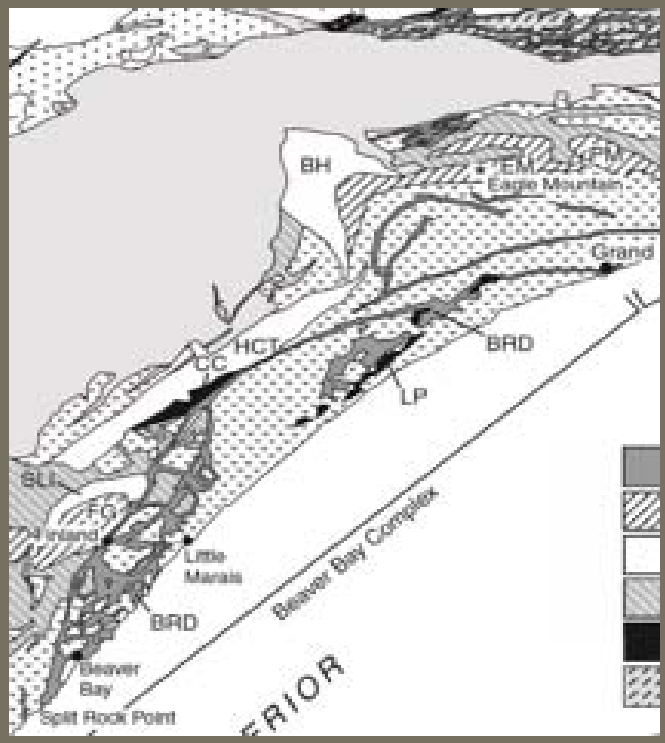
- Covers area of 600 square km
- Includes all intrusions from Split Rock Point to Grand Marais in the north and 20 km inland
- Intermediate to Mafic intrusions
- All classified as Diabase
- Higher elevation than North Shore Volcanic group rocks
- At least 13 major intrusive units and six intrusive events
- Broad range of parental magmas
- Creation closely associated with MRS main phase rifting

Miller (1997)



INTRUSIONS OF BBC

- Silver Bay Intrusions, Sonju Lake Intrusion, Shoepack Lake, Houghtaling Creek, Upper Manitou River
- Series of dikes, sills, or sheets
- Youngest Intrusion is Silver Bay Intrusion
- Reach depths of 10 km



BEAVER RIVER DIABASE

Photo by: Andie Oswald

BEAVER RIVER DIABASE

- Most aerially extensive intrusive phase in BBC
- Found in contact with all other BBC units
- Aphanitic mafic rock with abundant inclusions
- Northern Beaver Bay Complex
- Composite intrusions of olivine gabbro, ferrodiorite, quartz ferromonzodiorite, and melanogranophyre
- Ophitic olivine Gabbro
- Outside ring is coarse; inner core is strongly laminated and locally layered
- Silver Bay Intrusion is an outcrop

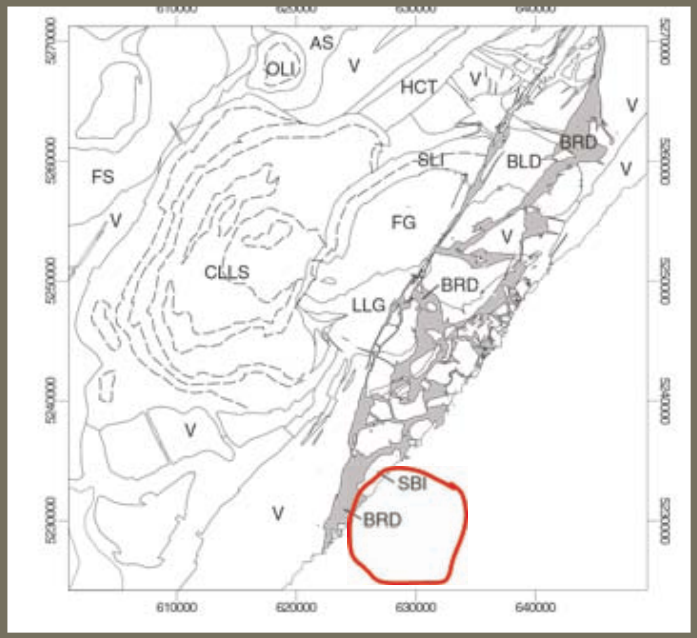
Miller (1997)
Miller and Green (2002)

SILVER BAY OUTCROP

Google Maps

SILVER BAY INTRUSION

- Youngest Intrusion in BBC
  - 1095.8 Ma
- Diabase
- Anorthosite inclusions
- Show extreme iron enrichment



ANORTHOSITE INCLUSIONS

- As much as several hundred meters in diameter
- Rounded to Angular inclusions
- Nearly PURE Anorthosite
- Display brecciaition and recrystallization textures
- Xenoliths
- Anorthosites were derived from a hot deep source
- Labradorite to Bytownite Plagioclase

GUIDING QUESTION

What is the whole rock chemistry of my sample, and how does it compare to other intrusions within the BBC?

Does the plagioclase in the Beaver River Diabase match the related Anorthosite inclusions?

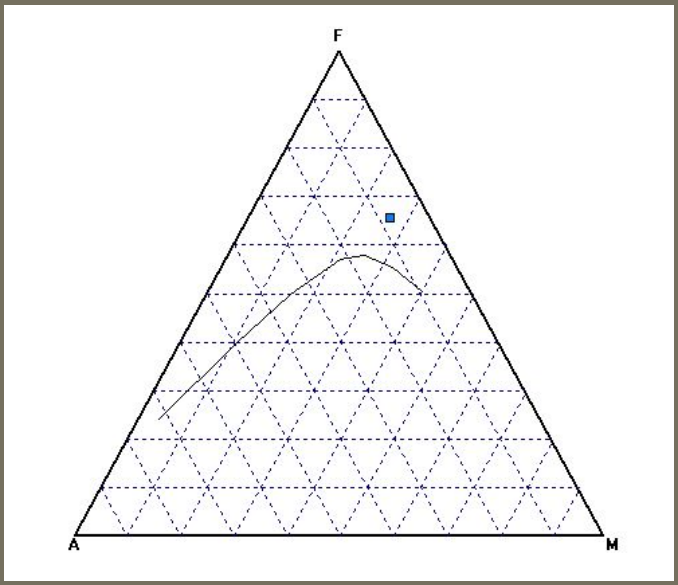
XRF

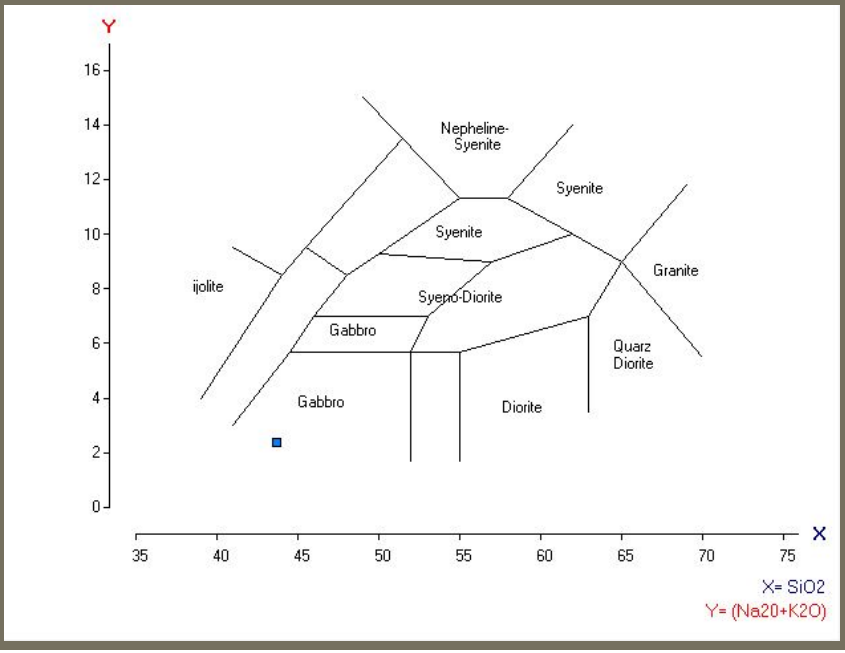
Procedure:

- Sample is crushed and powdered
- Powdered sample is pressed into a pellet
- X-rays excite electrons within the sample
- Secondary x-rays are measured
- Gives whole rock analysis using oxides

XRF DATA

- Expressed within an AMF diagram
- Expressed within a TAS diagram





MILLERS XRF DATA VS. SAMPLE XRF DATA

TABLE 1. PARENTAL COMPOSITIONS OF BEAVER BAY COMPLEX INTRUSIONS

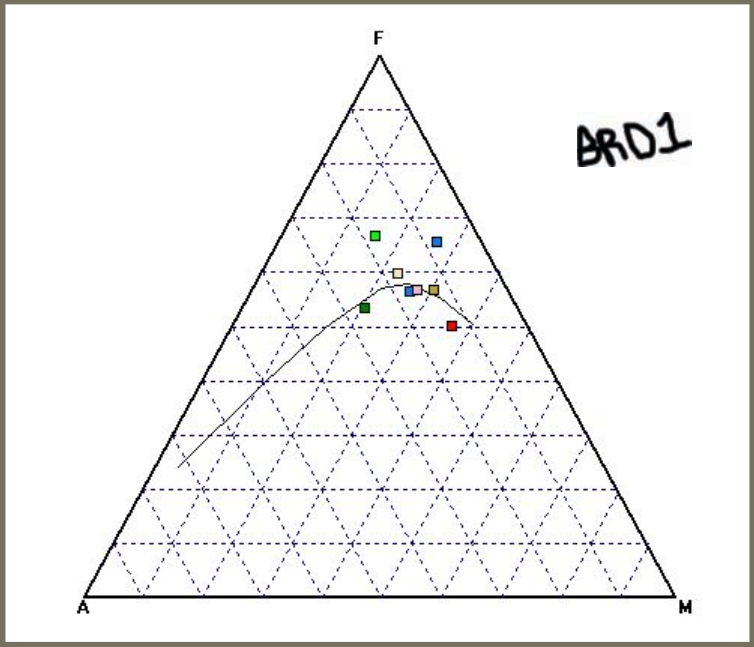
Unit*	Cabin Creek Porph. Diorite	Leveaux Porphyry	Lax Lake Gabbro	Blesner Lake Diorite	Upper Manitou River Gabbro	Finland Radar Granophyre	St. Sonju Lake Intrusion	Victor Head Diabase	Beaver River Diabase	Silver Bay Intrusions	North Shore Volcanic Group
Phase	Aphyric Facies	Aphyric Facies	Average Gabbro	Average Gabbro	Average Gabbro	Average Granite	Bulk Comp.§	Average Diabase	Marginal Diabase	Marginal Gabbro	Olivine Tholeiite**
Analyses	3	2†	5	5	12	9	84	3	12	12	14
wt. %											
SiO_2	53.5	53.5	47.7	49.5	48.3	73.9	48.4	49.7	48.0	49.5	49.5
TiO_2	2.30	2.45	2.27	1.70	1.64	0.30	2.22	1.71	1.31	3.25	0.80
Al_2O_3	12.5	13.5	16.2	18.6	16.3	12.5	13.9	15.9	16.7	12.4	18.2
FeO^t	14.7	13.4	12.5	9.4	11.6	3.0	14.6	11.2	10.5	15.4	8.4
MnO	0.20	0.16	0.19	0.14	0.18	0.05	0.21	0.15	0.17	0.23	0.13
MgO	3.2	3.4	4.8	3.63	5.7	0.1	7.9	5.3	7.8	3.6	8.8
CaO	6.8	7.1	9.7	10.21	10.2	0.6	9.1	9.5	10.4	7.8	11.4
Na_2O	2.81	2.83	2.74	3.80	2.58	3.60	2.54	2.57	2.30	2.85	2.38
K_2O	2.02	1.21	0.78	0.70	0.56	4.90	0.68	0.68	0.35	1.17	0.19
P_2O_5	0.41	0.42	0.24	0.14	0.14	0.07	0.30	0.25	0.14	0.47	0.06

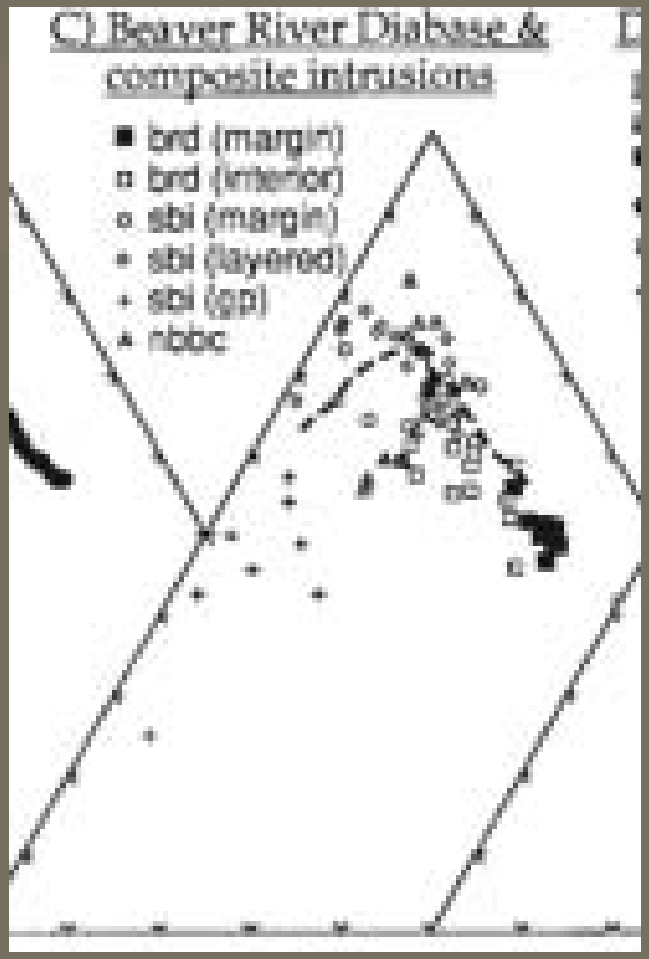
BRD Silver Bay

SiO2 (%)	49.5
Al2O3 (%)	14.6
FeO (%)	13.2
Fe2O3 (%)	11.9
CaO (%)	10.2
MgO (%)	9.7
MnO (%)	0.1
Na2O (%)	2.4
K2O (%)	0.2
P2O5 (%)	0.2
TiO2 (%)	1.2

XRF

Compared to other whole rock analysis of BBC intrusions in the literature

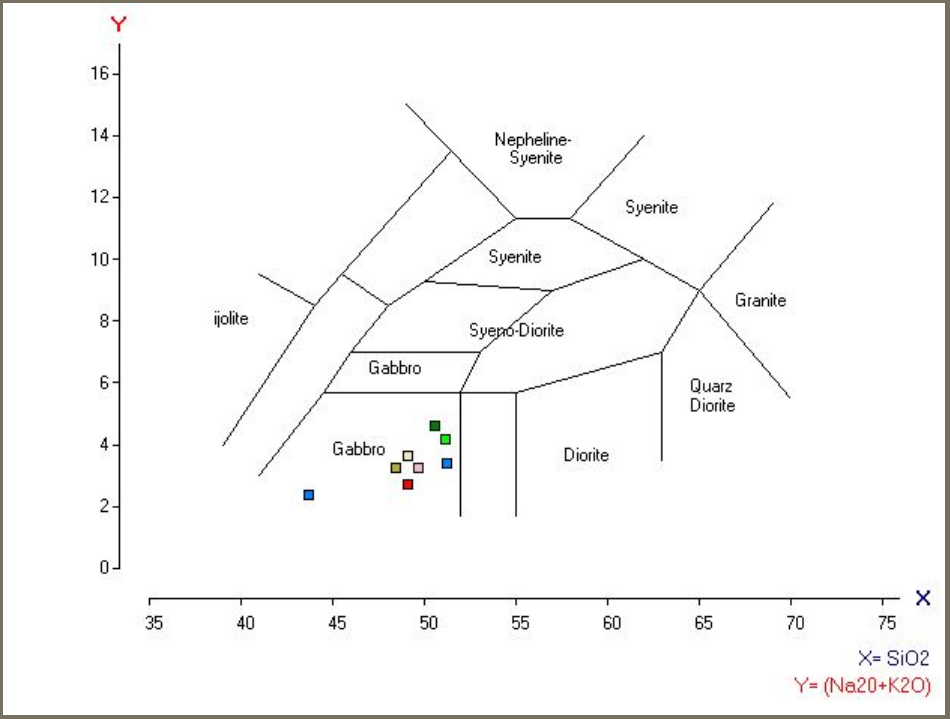



C) Beaver River Diabase &
composite intrusions
brd (margin)
brd (interior)
sbi (margin)
sbi (layered)
sbi (gp)
nbbc

Miller (1997)

XRF

Compared to other whole rock analysis of BBC intrusions in the literature



THIN SECTION

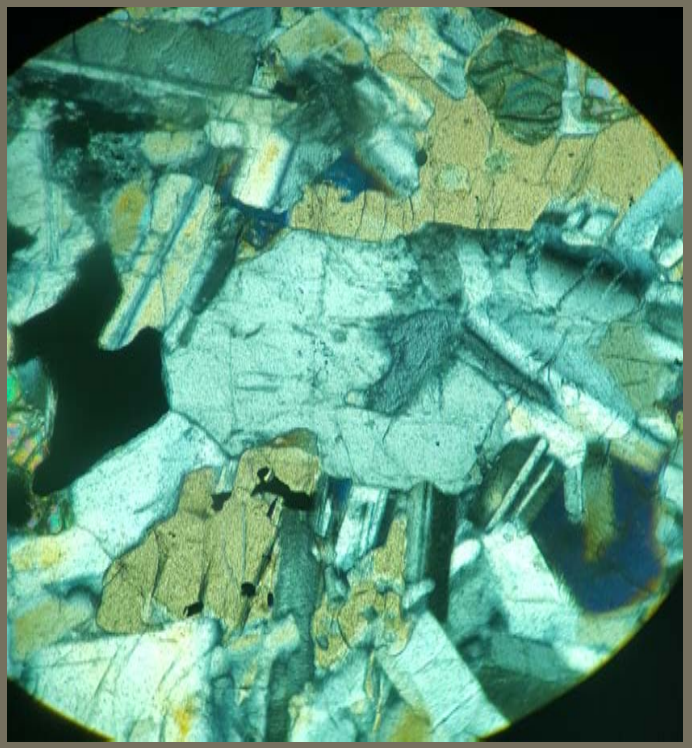
Procedure:

- Cut sample to a smaller size than clear slide
- Polish sample with grit
- Use epoxy to glue on slide
- Cut/ polish sample to 30 microns

- Used Soil Science Saw

THIN SECTION ANALYSIS

- Reverse Zoning
- Mostly Plag, Pyroxene, and Olivine



REVERSE ZONING PLAGIOCLASE

According to James Phemister in 1934, most cases of simple reverse zoning the cores are in a sense xenocrystic to the rock of which it now forms a part.

- Magma vs. Consolidated Anorthosite

Phemister (1934)

MICHEL- LEVY

Method

- Plag crystal must have North-South orientation, and have little twinning present
- Measure extinction angle

Results

- Andesine
- Anorthosite was Labradorite/ Bytownite

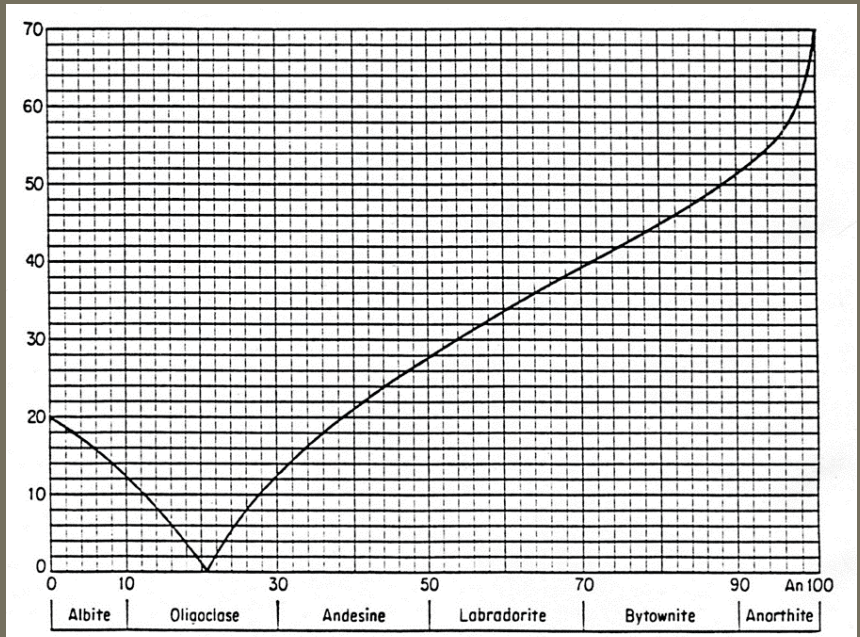


FIG. 13-26. Curve showing the maximum extinction angle of albite twins cut normal to (010) for the plagioclase feldspars (Michel-Lévy's method).

CONCLUSIONS

- Sample from Silver Bay Intrusion's geochemistry is similar to other diabase samples in BBC taken from Miller (1997), but has a few differences from other diabase. The Silver Bay sample from Miller (1997) does not perfectly match my sample from Silver Bay Intrusion

- The sample does not match the plagioclase of the Anorthosite but may or may not be related through reverse zoning

ACKNOWLEDGEMENTS

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