

Feldspar triclinicity, superheating and mineralization

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Abstract: The association of hydrothermal alteration and gold mineralization with Archean porphyritic felsic dykes swarms is a well-known feature. Examples are abundant in the Abitibi greenstone belt, such as Fenn-Gibbs or Lamaque. It has been frequently observed by the authors, in the course of routine petrographic work, that feldspar phenocrysts from such dykes ("FP" or "QFP") are monoclinic sanidine or anorthoclase, rather than the more usual orthoclase. It is estimated that about 50 % of the "QFP" occurrences are apparently sanidine bearing, suggesting an underlying process. Preservation of the high temperature structure of feldspar requires rapid heat dissipation in order to avoid inversion to triclinic feldspar or perthite. In hypabyssal or mesozonal conditions, it requires abundant fluids percolation. Such fluid inflow necessitates permeability, likely by fracturation, as indicated by the coeval pervasive sericite dominated hydrothermal alteration invading in the wallrock of the dyke swarm. Porphyritic felsitic dykes can be seen as the uppermost expression of larger magmatic chambers, linking it with the eruptive complex. Superheating evidences are abundant, such as phenocrysts resorption, similar to what is commonly seen in rhyolite and dacite.

Feldspars, under magmatic conditions, are monoclinic and form a complete solid solution between albite and orthoclase. Their inversion into triclinic structure occurs at about 700°C, where microcline and albite end-members exsolve into perthites. Orthoclase can preserve pseudomonoclinic structure and variable obliquity. The magnitude of this obliquity is potentially related to the cooling history of the intrusion, and is envisaged as a proxy of the cooling gradient.

Recognizing sanidine or anorthoclase from orthoclase can be done under the petrographic microscope, while accurate measurement of obliquity needs time-consuming 5-axis Federov's stage manipulations. The relation between optical obliquity and $d_{(13\ 1)} - d_{131}$ spacing by XRD are under evaluation, as well is the development of more efficient procedures. The effectiveness of the method is currently tested on a well-documented mineralized system at Osisko's Canadian Malartic deposit. In the event the premise works, it may provide a new tool to test the fertility of porphyritic intrusions.

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FELDSPAR TRICLINICITY, SUPERHEATING AND MINERALIZATION

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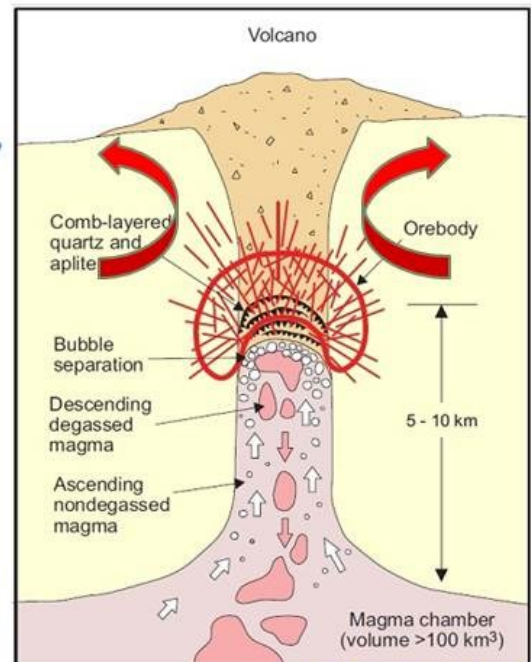
1: IOS Services Géoscientifiques Inc
2: Université du Québec à Chicoutimi
3: Corporation Minière Osisko Inc.

IOS Services Géoscientifiques inc

STARTING POINT

CLASSICAL PORPHYRY MODEL:

HYDROTHERMAL PROCESS WITH A MAGMATIC HEAT SOURCE.



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IDEAS!

QUESTION:

IF HYDROTHERMALISM IS DRIVEN BY COOLING OF MAGMATIC BODIES, IS THE MINERALIZATION RELATED TO THE COOLING HISTORY?

IS THE COOLING HISTORY RECORDED IN FELDSPAR CRYSTALLINE STRUCTURE?

CAN WE DEVELOP AN EXPLORATION TOOL FROM THESE PREMISSES?

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PROSPECTOR'S
KNOWLEDGE

IN ARCHEAN VOLCANOPLUTONIC
TERRAIN, MINERALIZATION IS
COMMONLY ASSOCIATED WITH
PORPHYRIC DYKES
« FP » or « QFP »

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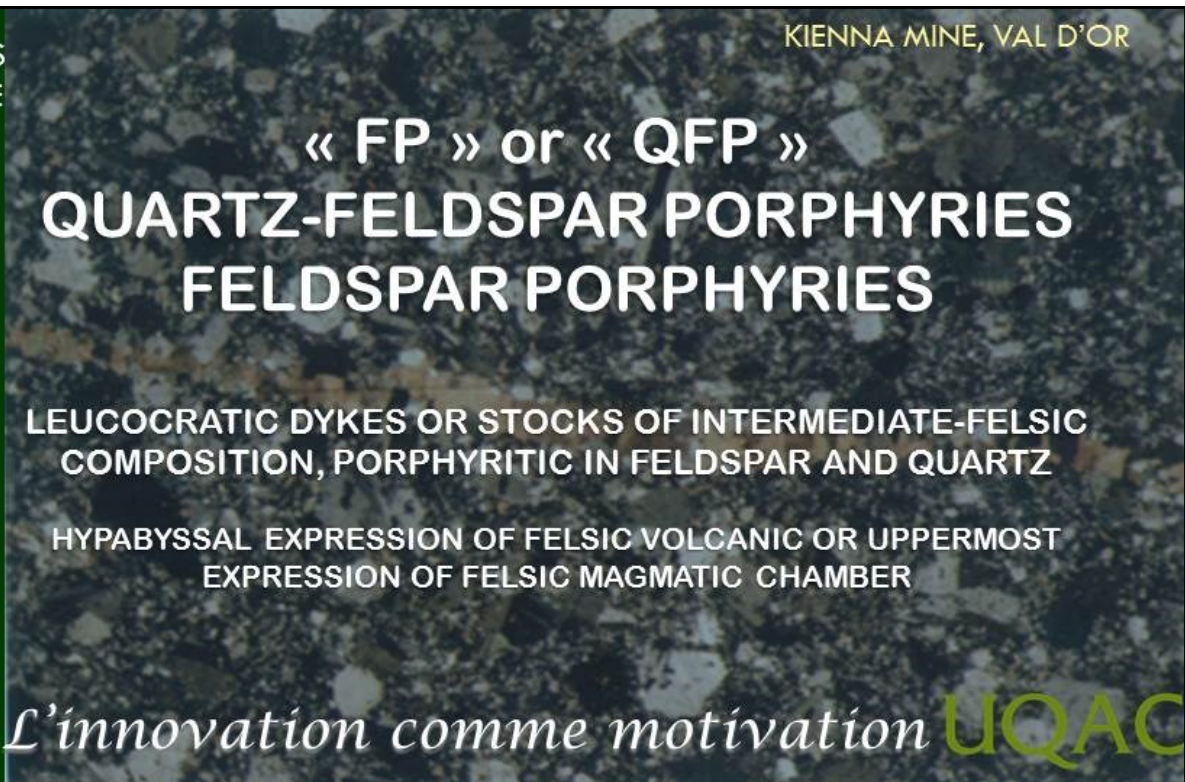


INDUSTRY'S KNOWLEDGE

Canadian Malactic, Osisko

IN ARCHEAN VOLCANOPLUTONIC TERRAIN, **MINES** ARE COMMONLY ASSOCIATED WITH PORPHYRIC DYKES
« FP » or « QFP »

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GEOLOGIST'S KNOWLEDGE

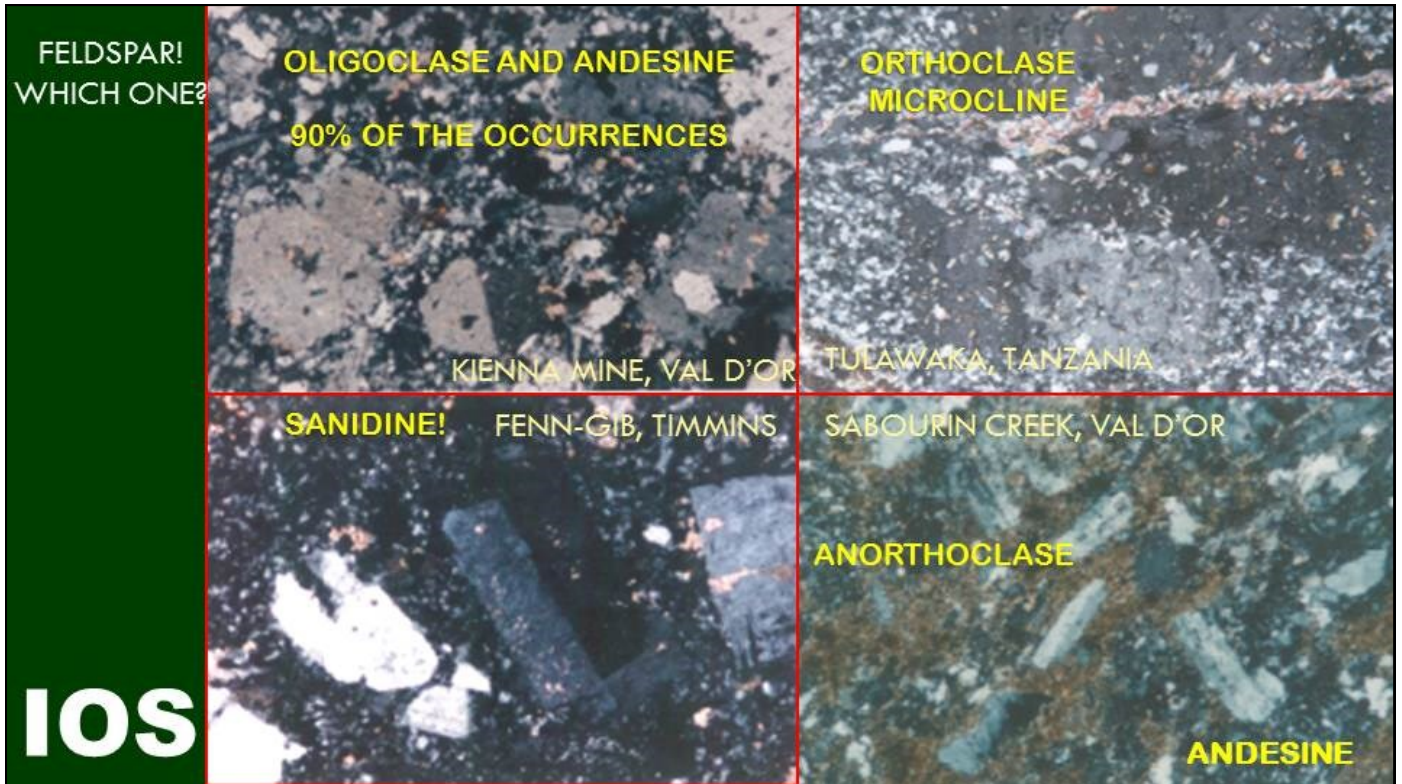
KIENNA MINE, VAL D'OR

« FP » or « QFP »
QUARTZ-FELDSPAR PORPHYRIES
FELDSPAR PORPHYRIES

LEUCOCRATIC DYKES OR STOCKS OF INTERMEDIATE-FELSIC COMPOSITION, PORPHYRITIC IN FELDSPAR AND QUARTZ

HYPABYSSAL EXPRESSION OF FELSIC VOLCANIC OR UPPERMOST EXPRESSION OF FELSIC MAGMATIC CHAMBER

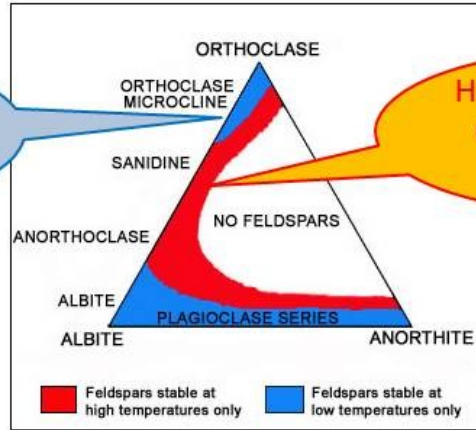
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FELDSPAR SERIES

HIGH TEMPERATURE FELDSPARS

LOW TEMPERATURE:
DISCONTINUOUS
SOLUTION



HIGH TEMPERATURE:
COMPLETE SOLID
SOLUTION

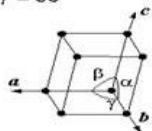
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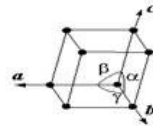
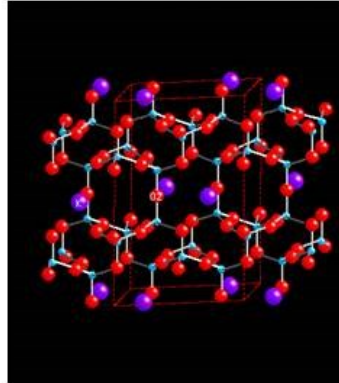
A QUESTION OF POLYMORPHS

SANIDINE



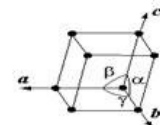
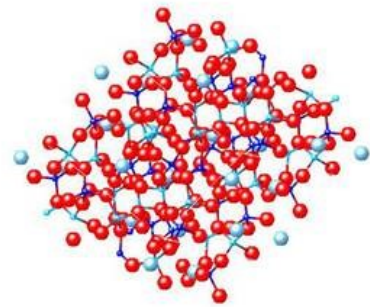
Monoclinique

ORTHOCLASE



Pseudo-monoclinique

MICROCLINE



Triclinique

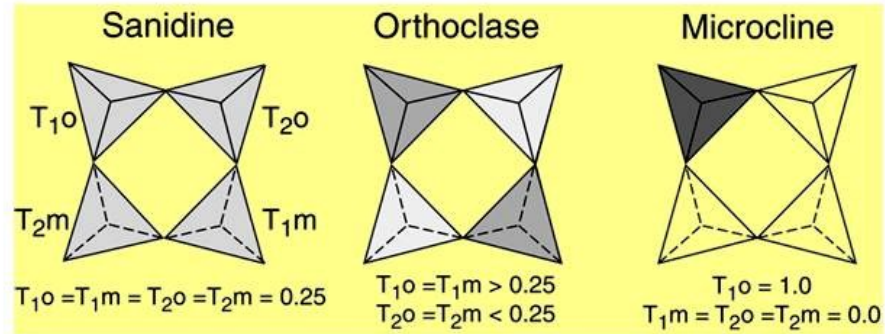
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A QUESTION OF DISORDER

DISTRIBUTION OF AL⁺⁺⁺



Al⁺⁺⁺ is randomly distributed among tetrahedron

Al⁺⁺⁺ always in the same tetrahedral site

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A QUESTION OF TEMPERATURE

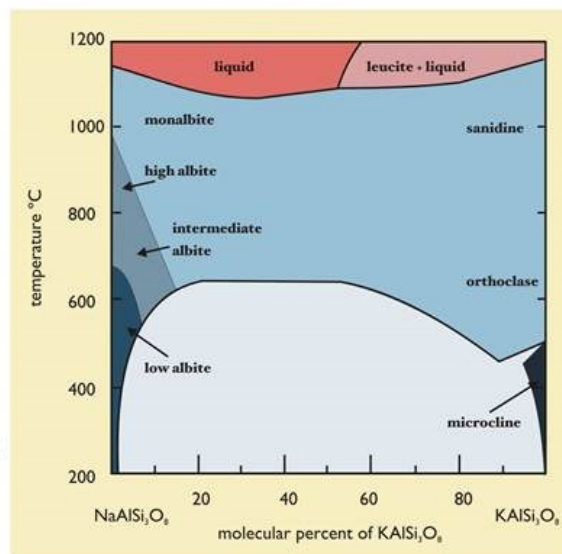
ORDERING DEPENDS ON TEMPERATURE

MAGMA

METAMORPHISM

HYDROTHERMALISM

SURFACE



SANIDINE

ORTHOCLASE

MICROCLINE

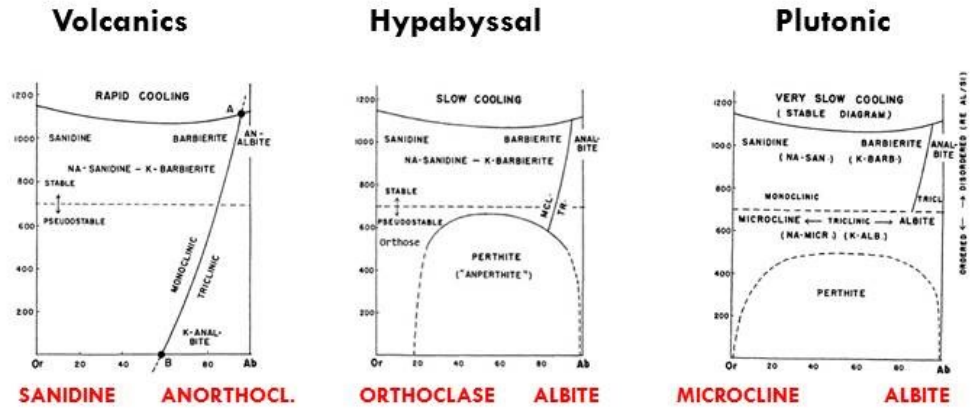
ORDERING

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A QUESTION OF TEMPERATURE

FELDSPAR AND COOLING RATES



Smith 1974, Laves 1952

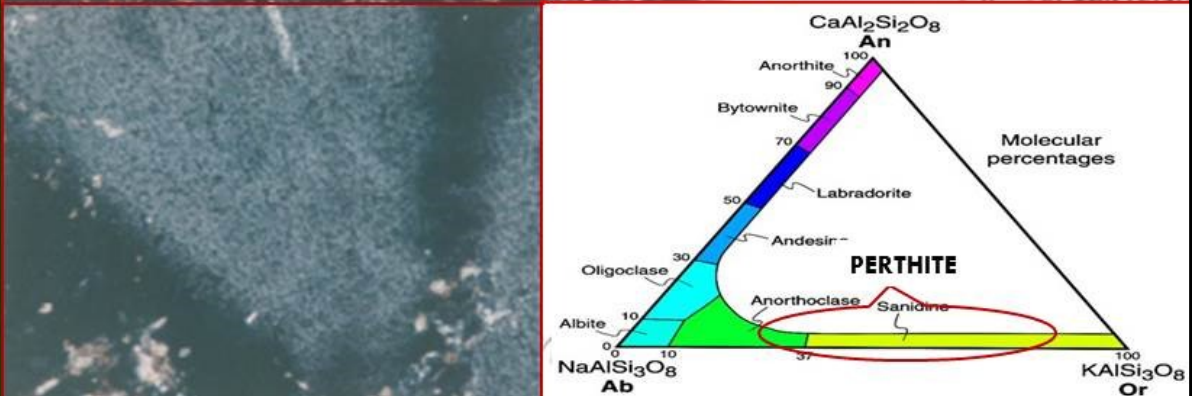
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A QUESTION OF DROP

SLOW COOLING: INVERSION SANIDINE → PERTHITE, CRYPTOPERTHITE TULUWAKA, TANZANIA

FENN-GIB, TIMMINS



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A QUESTION
OF
CHARACTER

HOW DO WE DISCRIMINATE FELDSPAR?

ALTERATION AND TWINNING: EASY
CALSBAD TWINNING ONLY: DIFFICULT

VALLEJO: COLUMBIA

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BEWARE!

CRYSTALLOGRAPHIC CHARACTER

	SANIDINE	ORTHOCLASE	MICROCLINE	PLAGIOCLASE
2V	-	-	-	+/-
2V (np)	0-40°	30-80°	40-90°	80-105°
Np \wedge a	0-9°	3-12°	18°	-10° - +10°
Fastl.	-	-	-	-
TWINS	Carlsbad	Carlsbad	Checkboard	Carlsbad (Albite)
Nm	1.53	1.525	1.52	1.53-1,545
Ng-Np	0.006	0.006	0.007	0.007-0.008

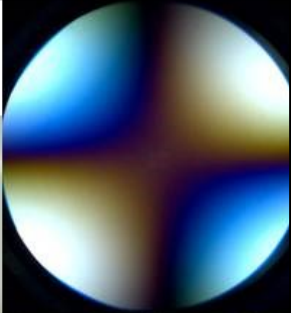
CONSEQUENCE: SANIDINE MAY STAY UNNOTICED

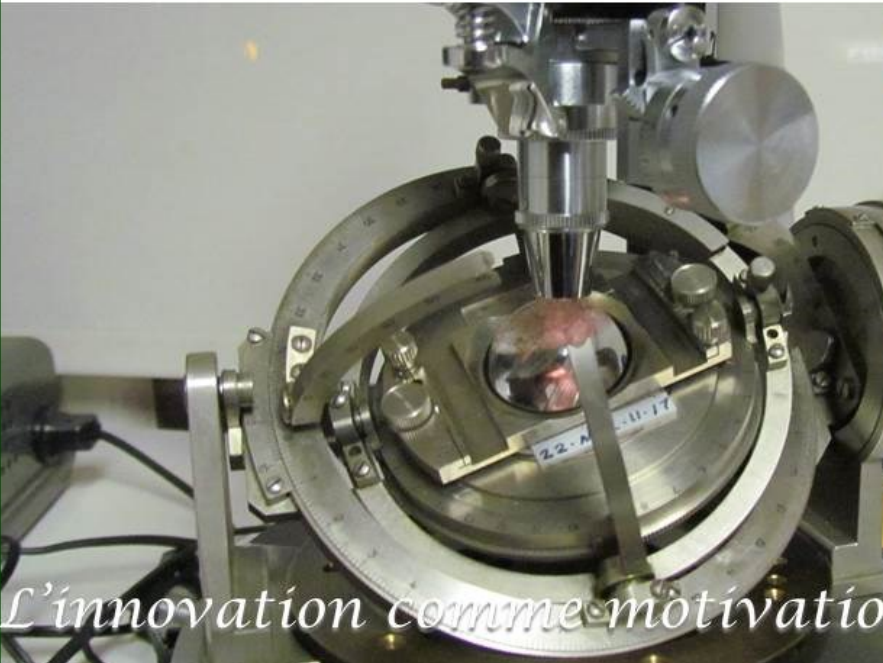
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SOLUTION FROM THE MUSEUM

5-AXIS FEDEROV STAGE





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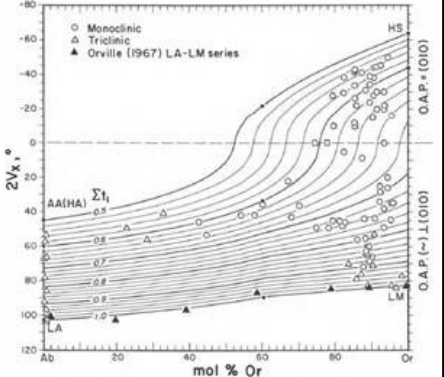
OLD KNOWHOW!

DISORDER MEASUREMENT

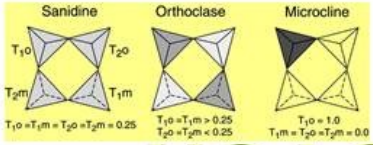
- DISORDER RELATES TO 2V
- Monoclinic, OAP \parallel (010)

$$\sum T_1 = 2T_1 = 0.665 - 0.711\sin^2 V_x$$
- Mono or triclinic, OAP \perp (010)

$$\sum T_1 = T_{1o} + T_{1m} = 0.665 + 0.711\sin^2 V_x$$



Su (1986)



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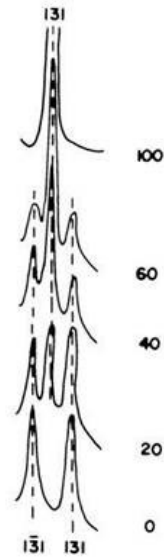
OLD
KNOWHOW!

MICROCLINE OBLICITY FROM XRD

- Obliquity of feldspar (Δ) is measured by the distance between d_{131} and $d_{1\bar{3}1}$ from X-ray diffraction patterns

$$\Delta = 12.5 (d_{131} - d_{1\bar{3}1})$$

MIXTURES OF STANDARD MINERALS
ORTHOCLEASE AND MICROCLINE



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TOOL BOX

- ➡ 2V from Federov stage
- ➡ XRD on powder
- ➡ Cathodoluminescence
- ➡ Raman spectrometry
- ➡ Micro-XRD
- ➡ EBSD

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FRESH BRAINJUICE!

C. POTVIN-DOUCET
M.Sc Thesis on Canadian Malartic case

Thanks to:
Mitacs

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TEST ZONE!

Osisko's Canadian Malartic deposit

Plan géologique du camp minier de Malartic

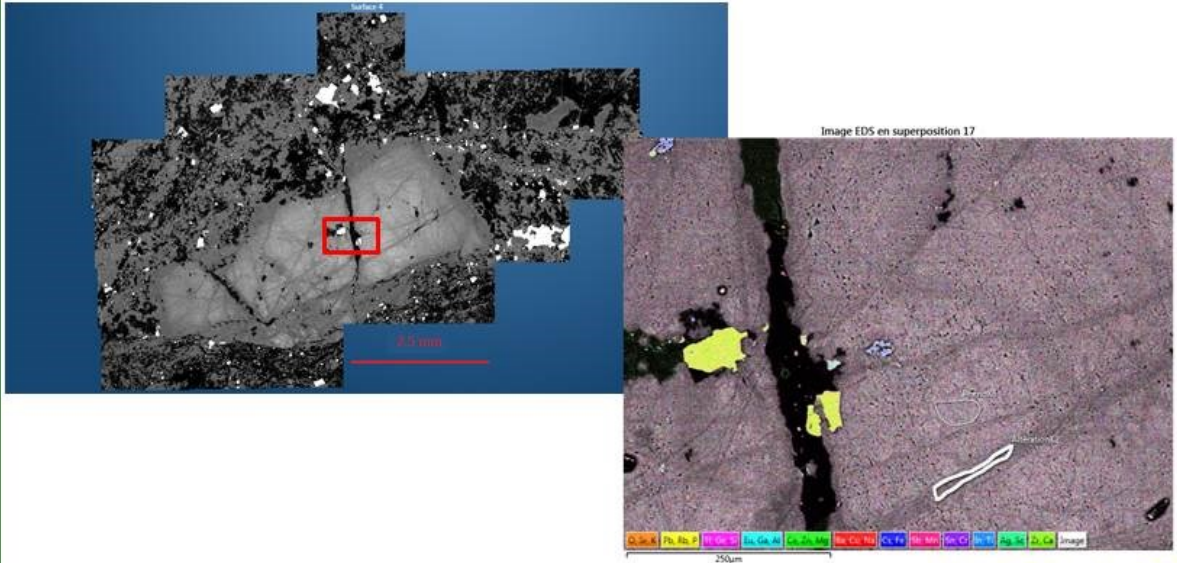
★ 2014 Samples

Fallara et al. 2000

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PRELIMINARY TESTS

1: COMPOSITION OF FELDSPAR: SEM-EDS



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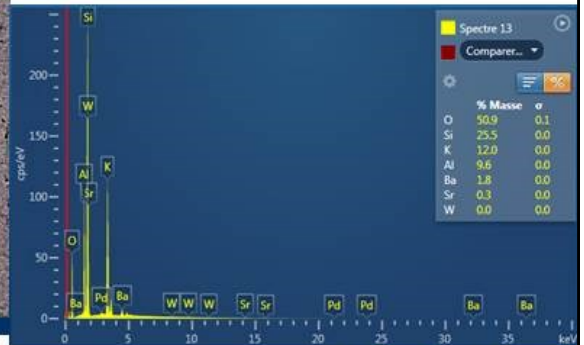
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ORIGINS MATTER

1: COMPOSITION OF FELDSPAR: SEM-EDS



- CORE
 - No Ca or Na
 - Ba: 1,8% to 2,2%
 - Magmatic
- Rims: No Ba
 - Hydrothermal

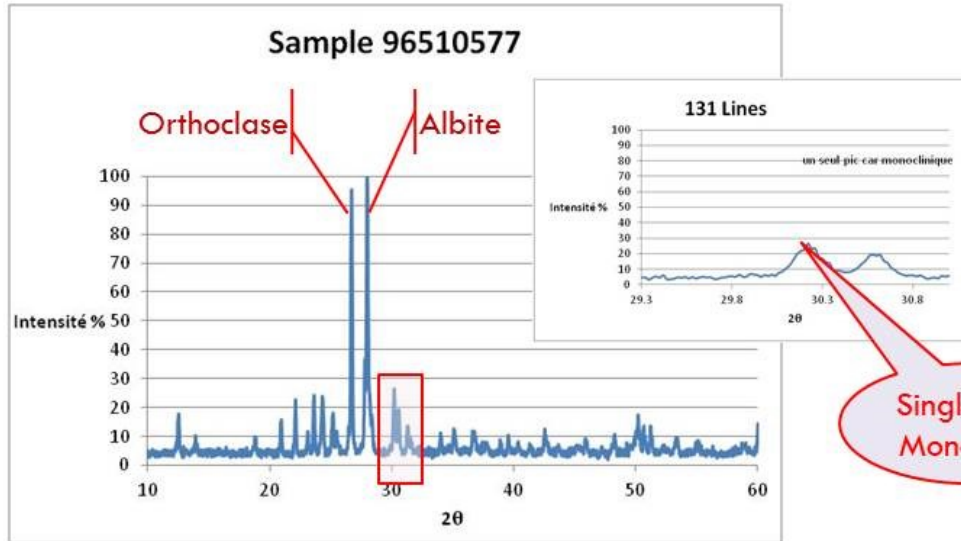


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WORK IN
PROGRESS

3: OBLICITY MEASUREMENT: XRD



PROBLEM: MIXTURE OF FELDSPARS

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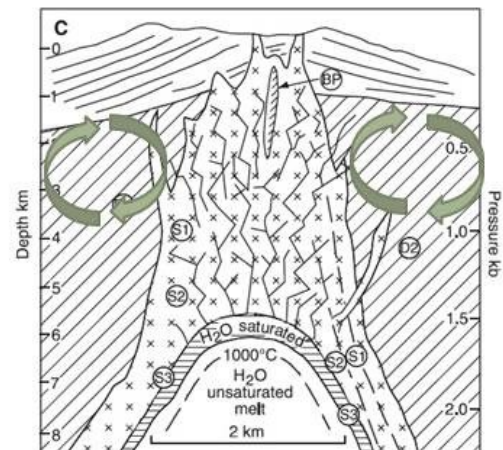
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THE GREAT
QUESTIONS!

PRESERVATION OF HIGH-T FELS → QUENCH

- ⚡ HOW CAN HIGH-T FELDSPAR BEING PRESERVED IN INTRUSIVE ROCKS?
- ⚡ HOW CAN FELDSPAR STRUCTURE BE USED AT COOLING INDICATIONS?
- ⚡ IS COOLING RATES RELATES OR TRIGGS HYDROTHERMAL VIGOR?
⚡ **BECAUSE MINERALIZATION RELATES TO HYDROTHERMALISM!**
- ⚡ HOW DOES HIGH TEMPERATURE STRUCTURE BE PRESERVED DURING HYDROTHERMALISM?



Pirajno 2009

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TOOL BOX

If it is demonstrated,

**can we develop a practical exploration
guide?**

Maybe!

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