Thesis

Material

M.Sc. R.V. Kirkham.

Kerr, Paul F., J. L. Kulp, C. Meade Patterson, & Robert J. Wright.
"Hydrothermal Alteration at Santa Rita, New Mexico,"
Bulletin of the G.S.A. vol. 61, pp 275-347, April 1950

Four Stages of Alteration of Santa Rita Intrusion
① Areas of negligible alt.
② " " significant visible changes of feldspars & ferro-magnesian minerals
highest conc. of copper * ③ " " Argillic alteration
④ " " Sericitization & silicification

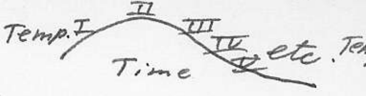
- Santa Rita Intr. (Whim Hill Br.) - is center of alt. zones
- Pre-alt. = Hanover Intr. = granodiorite porph. -
pheno. - plag. 70%, Hb. 10-20%, & bio. 5% - bio. more common in S. Rita.
ground mass - (40-70%) ?? (qtz 10-15%)
accessory sphene, apatite & zircon
Solidification & Fracturing - mineralization dependent on porosity
- Stages of Mineralization
1. - Magnetite (+ orthoclase) - cement of Whim Hill Breccia
Aplitic injection
2. - Pyrite & minor molybdenite
- " is ubiquitous in granod. - & replaces the magnetite
- Qtz. Porphyry Dykes - Divide region into early & late mineralization

— " —

Chalcocite is main ore mineral — here thought both hypogene & supergene.

Hydrothermal Alteration (4 above stages) arbitrary division (for field mapping)
① Feld. clv. - fresh lustrous no clay patches fresh bio.
② Felds. dull & cloudy - occasional " "
↓ Kaolinized - biotite - chloritized
③ Hydromica - argillic alteration - Relict clay pseudomorphs of feld. - Brown hydromica replaces biotite (check K.M.T.'s course)
- Ground mass clay (qtz + kaolinite
- minor qtz. veins
↓ Feld. alt completely to Ser. + Qtz.
④ Relict feld. outlines obliterated
" bio " "
Groundmass high in sericite & qtz - - mosaic of qtz & sericite with few muscovite XTLS.
Alunite veinlets are common
Quartz " " abundant

My comments
Possibilities
stages of alteration possibly related to: ① Temp. flutuation
② Release of volatiles after crystallization



Temp. ↓ I volatiles enclosed after crystallization
II - V volatiles released
↓ VI volatiles inclosed
VII last crystallization from volatiles

Aug. 1953.

Vol. 64. pp. 945-992 Bulletin of the Geological Society of America

Granitization and Hydrothermal Alteration at Bingham, Utah.

by Bronson Stringham

pg 77 Seven stages of Hydrothermal alteration

I. restricted in area - kaolinite & illite from feldspar
- only sl. K_2O & CaO removed & SiO_2 added
- cut by veinlets of other stages.
kaolinite - forms principally in acid soln. below 350°C

diss. throughout rk. & don't follow fractures

* sol'ns. uniformly soaked the rock

II extensive sericite and hydrothermal biotite (all rks. within mine)
intensity varies - Fe Mg added
- Gruner 1944, p. 587 Ec. Geol. - sericite forms in acid sol'n. above 350°C
- alkaline solns. below 350°C
- neither ph (?) or temp. is known.
- Fe 1.88% to 3.74 - lead to biotite formation.

III profuse - in restricted areas - chlorite and hydrothermal biotite
- in granite in wide bands, obviously // fractures - few mm. to over 200'.
- much Fe & Mg added.
2.7 Fe to 5.4
4.1 Mg to 5.44.
- chlorite vague but thought slightly alkaline
- but bio. with sericite could form below 350°C in alkaline. 100° - 400 500°C

followed channels

IV Quartz and sericite - formed on sides of fractures in bands and in all the rks. of the area
- Si added
- symmetrical on sides of fracture
- V glassy Qtz. VI sulphides filled same fractures.
Fe + Mg moved to border of band
i.e. "Basic front"
- no temp or press.
removed MgO Fe_2O_3 + Na_2O
Si 60-68% - 72%
+ very good
3 mm separation

V sharp bordered veins - no accompanying alteration
- Si added Fe + Mg ~~of biotite moved to border of band~~
- sulphides in vugs.

soaked VI diss. sulphides - no accompanying alteration
Cu, Mo, Fe, S (As) minor added
Au Ag
hydroth. sulphides
- digenite
- chalcopyrite
- bornite
- enargite
- molybdenite
- pyrite

not studied in detail - just general hydrothermal history.

VII in cracks & vugs in restricted areas - sericite & allophane
K Al SiO_2 H_2O
porcelain-like

* - chalcopyrite diss. throughout & not in veinlets.
- bornite in lower levels of pit. " " "
- molybdenite is assoc. with Cu minerals

- chalcopyrite, enargite, moly. & pyrite in stage V
* - sulphides seem to favor positions adjacent biotite lacking which.
* - ?? how did the uniform soaking occur & not just vug filling.

microscopic properties

① kaolinite - readily identified
- low bir. (007) - individual crystals of aggregates may appear isotropic
- typical wormlike structures with traverse flates
- n slightly > Qtz.

② Illite - higher bir. than kaolinite - first order yellow
- distinctly flaky
- length slow
- n low ≃ 1.569 sl. > kaolinite
- may be in grid with kaolinite (.05 mm)

③ Sericite - distinguished principally by its lack of color.
- high bir. - intense 1st order colors to sec. red.
- flaky form
- intermediate n low ≃ 1.56
- found mainly in feldspar.

My Comment ? large sphene represents new field in phase diagram for high volatile content.

Gilluly, James. The Ajo Mining District Arizona. United States Department of the Interior. Professional Paper 209, 1946

- richest ore is in highest altered zones - bands of orthoclase pegmatite.
- oxide ore grade ≃ grade sulphide ore ∴ no enrichment

malachite - minor azurite chrysocolla
cuprite hematite
tenorite limonite
a little chalcocite

- mainly chalcopyrite
some bornite
& minor pyrite
trace Au, Ag, Moly, sphal.
tennantite
considerable magnetite & specularite

different ← from other porphyries

- sulphides in veinlets & discrete veins
- plagioclase to chlorite & sericite
- ↑ Extensive orthoclase & Quartz gangue with ore emplacement

different from other porphyries - usually chalky from argillic feld. alteration

- Cornelia Qtz. Monz.

① contact sharp except in mineralized areas.
② - Independant of country rk. structures
③ - no effect on structure of wall rocks
④ - Where the country rk. has been contact-altered it is massive hornfels, not schist.
⑤ - no reworking of Cardigan (injection) gneiss.
⑥ - no arching or doming.

Cornelia Qtz. Monz. has many facies
- fine grained, equig. Qtz. diorite (mappable unit)
- equi. Qtz. Monz.
- plag. pheno. k.-matrix → porphyritic " "
- aplite & pegmatite

} gradational

P 27-28 - (equigranular) Qtz. monz. - discription fits Michell Cr. Porph.
- sporadic pheno.
- Commonly more or less altered
- actinolite after Hb.
- chlorite & epidote after all minerals
- sericite & albite after plag.
- mylonite zones - broadleaved muscovite.

*even - conspicuous sphene to 3 mm.
microperthitic ortho. & micro. → - pink k-feld.
- usually white plag. strongly zoned An45 to An20 (An50 to An10)
- biotite from Hb. from Augite to chlorite

Alteration - much more widespread than metallization

intimate connection with magmatic processes ←

① - impregnation of rks. with k-feld. & Qtz. (late & postmagmatic) — poikilitic k-feld embayed-corroded Qtz.-Plag. pheno.
② - plag. to aggregates of albite & sericite
③ - dark minerals to chlorite
④ - more localized introduction of metallic min's. magnetite, pyrite, chalcopyrite, bornite, molybdenite, & specularite

- lack of flow lines in intrusion ∴ fluid at emplac. - not crystal mush with high viscosity
- " " dykes - stoping ??

P109 - Gold ore is associated with diss. alunite.

② Gilluly

① Check for fractures in T.S.

P73 <u>Postmagmatic Modifications in and near the New Cornelia Ore Body</u>

- cupola was shattered & cracked over a considerable area and was permeated by solutions of magmatic derivation.
- much introduced material
- alteration controlled by fracturing.

*- only scanty pyrite

- ~~pp~~magnetite, pyrite, chalc. ⇌ & bornite paragenesis with qtz. & chlorite all the time.
  - ankerite, dolomite, calcite, minor anhydrite & barite.
  - " - barite assoc. with specularite
  - alunite occurs as veinlets & stockwork in Concentrator Volcanics
    It is not assoc. Cu min.

- he tests "zonal theory."
  ① - pegmatite, orthoclase, leafy chlorite, and magnetite are closely group — controlled by same channels.
  - qtz. is most abundant near pegs. but also broader occurrence high pyrite areas.
  - pyrite higher conc. away from pegs.
  - sericitization assoc. with pyrite
  - high-grade hypogene copper follows pegs,
  - moly. is sparse.
  - spec. no consistent relation
  - - pegs. are central part of ore body.

Volatiles - H_2O & S.
- probably also halogens, Carbon, H, B. & N. & metals
- spec. isn't assoc. with other metals, ∴ discontinuity in mineralization
- Ferrous Fe is oxidized late in magmatic history by (high) partial pressure of O_2 — widespread alteration of magnetite to specularite — hypogene oxidation of iron in the ore body
  - no evidence of $FeCl_3$ transport

P81 <u>Summary of ore Deposition</u> My comment for Mickell 1st some granitization by soln. charged with alkalis & silica - Tuttle & Bowen.

① Direct continuation of consolidation of Cornelia Qtz. Monz.

② Enrichment of magma in lower melting components

Smith, J. R. and ~~H.S.~~ Yoder, H.S., Jr. Variations in X-Ray Powder Diffraction Patterns of Plagioclase Feldspars. The American Mineralogist, Vol. 41, 1956, pp. 632-647.

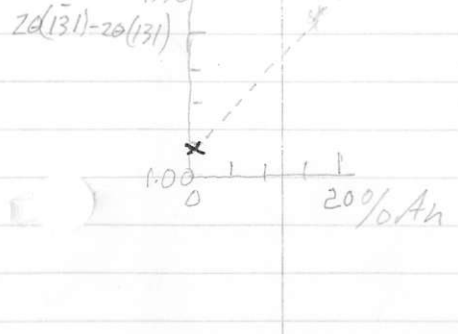
abstract
- dry synthetic plag. - distinct curve from natural magmatic
  - " hydrothermal plag., volcanic & hypabyssal plag. are intermediate between the curves.
- but some anomalous plagioclases ("low temp." series)

*** It is concluded that composition determinations cannot be made by the use of the available curves based on the variation of reflection separation, because there is no a priori way of knowing how closely a given plagioclase is represented by a particular curve. - - -

$(1\bar{3}1)-(131)$ oscillate between $\overset{(.3)}{29.0}$ & $\overset{(31.7)}{32.0}$

(mine) * - use curves to find structural state (state of inversion) of plag. & may give composition.

P641

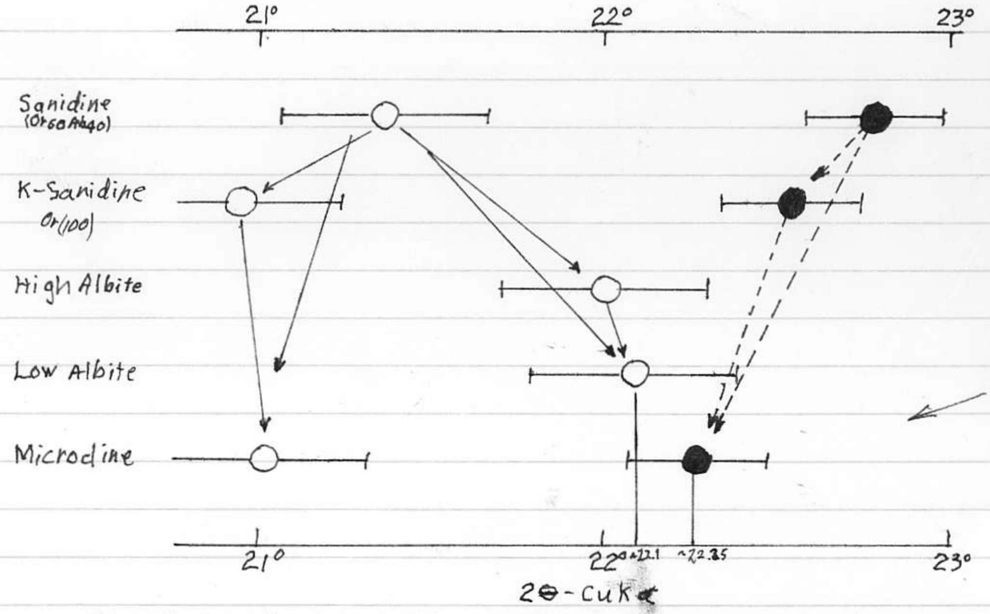


Bowen, N.L. & Tuttle, O.F. - The System $NaAlSi_3O_8$-
$KAlSi_3O_8$-H_2O. The Journal of Geology
September 1950, Vol. 58 No 5. pp489-511

Kuellmer, Fredrick J. ~~X~~ X-Ray Intensity Measurements on Perthitic Materials. I. Theoretical Considerations. The Journal of Geology. Vol. 67, November 1959. pp 648-660

P653: Phase diagrams of the alkali feldspar system based on laboratory work (Tuttle and Bowen, 1958), as well as natural minerals (Laves, 1952), demonstrate that unmixing of originally homogeneous alkali feldspar should, if complete, produce two phases with the compositions of nearly pure albite and nearly pure potassium feldspar.

- $(\bar{2}01)$ spacings for pure albite & orth. is 0.20Å or $\boxed{1.04^\circ}$ 2θ (for Cu Kα radiation)
- (111) line of microcline may interfere with $(\bar{2}01)$ of albite. (Fig. 1)



note can distinguish when 1° 2θ = 4 chart divisions

May 23rd
K-22A

Reference (to look-up) Laves, Fr., 1952, Phase relations of the alkali feldspars: Jour. Geology, vo. 60. pp. 436-450, 549-574.

MacKenzie, W.S., 1952, The Crystalline modifications of $NaAlSi_3O_8$: Am. Jour. Sci., v. 255, pp. 481-516.

& Smith, J.V., 1955, The alkali feldspars. I: Am. Mineralogist, vo. 40. p. 707-732.

—— 1956, The alkali feld. III: Am. Min., V. 41, p. 405-427.

1955, " " " II: " ", v. 40, p. 737-747

Smith 1956, The Powder patterns & lattice parameters of plagioclase feldspars. I. the soda-rich plag: Min. Mag., v. 31, p. 47-68

Feldspar Investigations

Orville, P.M. Annual Report of the Director of the Geophysical Laboratory (Carnegie Institution of Washington) 1957-1958 pp 206-209.

-use $KBrO_3$ internal standard (good-reasons given pp 208)
$2\theta = 20.205° \pm 0.010°$ — =(101) peak.

P209. The average difference between the two values of $\Delta 2\theta$ for the triclinic and monoclinic form of each sample is 0.015°, which is equivalent to 1.5 weight % Or.

↓

∴, graph may be used for low temp. forms for close estimate

V. Imp. * Min. Mag. (June '54) W. S. Mackenzie – The orthoclase – microcline inversion P354
" " (March '54) Plag. indentification

Amist P.P. Or 93.6 %
Ab 5.4 %
An 1.0

V. Imp. * Hewlett, C. G. Optical Properties of Potassic Feldspars. G. S. A. Bulletin, Vol. 70, No. 5, May 1959. pp 511–538

- Ba, Sr + Rb may be found in the feldspar structure.

P515 – wide range in 2V – a̲ range in divalent cation
or b̲ variable degree Si/Al ordering
– range may be measured in single zoned crystal.

– optic plane may be normal (N) or parallel (P) to the symmetry plane (010).
– for some samples it is both N + P (in different xtls)

P518 Variations in Optical Properties of Potassic Feldspars
due to ① substitution – Fe^{3+} for Al
– Na, Ca, Ba, Sr, + Rb for K
& Al for Si – to balance electrostatic charges.

② Presences of sub-microscopic twinning.
– or intergrowths (eg. perthites)
– or inversion Or. to microcline etc.

③ Degree of order of Al + Si within tetrahedral sites (This may reflect partial inversion from "high" phase to "low" phase or unmixing of phases of different Si : Al ratios.)

* The exent + scale of unmixing is influenced by original composition.

– Close Comparison between composition $d(\bar{2}01)$ + chemical analyses.
– for composition (homogenized) $d(\bar{2}01)$ – (Ionic Radius) Na (0.98) + Ca (1.06) reacts same
∴ for finer ~~reduction~~ – K (1.33), Sr (1.27), Ba (1.43), + Rb (1.49)
need chemical analysis.
* – anomalous results – homogenization may cause metastable expansions in lattice (∴ can't rely on results)
* – can't tell K/Na ratio by refractive indices + ext. angles – trace element subst far too important

P537 * – Zoning + Variation in 2V are usually accompanied by a variation in the α Index; ∴ the zoning in not likely due to K/Na ratio but rather due to substitution of divalent ions (Ba?, Sr?, + Rb? etc) for K or possibly Fe^{+3} sub.

Min. Mag. - March 1956 P41-47

The Orientation of pericline twin lamallae in triclinic alkali feldspars.

W. S. MacKenzie

albite law

-reflection across (010) plane or 180° rotation about an axis ⊥ (010) - composition plane is (010)

pericline law

-180° rotation about b-axis - comp. plane is an irrational plane that contains b-axis & intersects (010) in a line ⊥ b-axis. This plane is known as the rhombic section.

- microperthitic albite ⊥ (010)   -107 ½°   trace (001)
  or +72½   "   (010)

- microcline twinning is not readily observed on section ~//(010) & may be untwinned

∴, difficult to disquish from orthoclase

An_{1-5} -21$_{-25}$ unmixing in plag.

* Good, Critical Paper

J.V. Smith, Min. Mag. March 1956 P47

The Powder patterns & lattice parameters of plagioclase feldspars. I The soda-rich plagioclases

- from powder patterns can't tell comp. between An_{0}-An_{02}
- If composition is known the powder method may be used for the determination of the thermal state.
- If plag. is low temp. then can judge comp. to 2 % An.

need to approx. plag. comp. by ref. ind.

- Specimens that are taken from large plutonic rks. or regionally meta. rks. should be low temp.
- Specimens from volcanic, hypabyssal, & small plutonic masses must be regarded as uncertain.

*- in peristerite region take center of gravity of peaks and not just strongest peak.

- he says don't use Bowen & Tuttle's $\bar{1}31$ & 131 in peristerite region use (111) & $(11\bar{1})$ $-2\theta_{Cu}$ 23.6 ± 0.1° & 23.0 ± 0.1°
& $(\bar{1}32)$ & (131) - 33.85 ± 0.1 & 31.4 ± 0.15°
- most methods used - peaks split in this region

The Alkali Feldspars V. The Nature of Orthoclase and Microcline Perthites + Observations concerning the Polymorphism of Potassium Feldspar
J. V. Smith + W. S. Mackenzie
Am. Min., vol. 44, NOV.-Dec. 1959
P1169 - 1185

out of 32 specimens of ortho. + micro.
K-phase - 14 monoclinic
- 4 triclinic
- 15 both tri. + mono.

pure
2 Na
3 K
remainder perthitic
5 anorthoclase
23 albite - oligoclase
2 may contain both

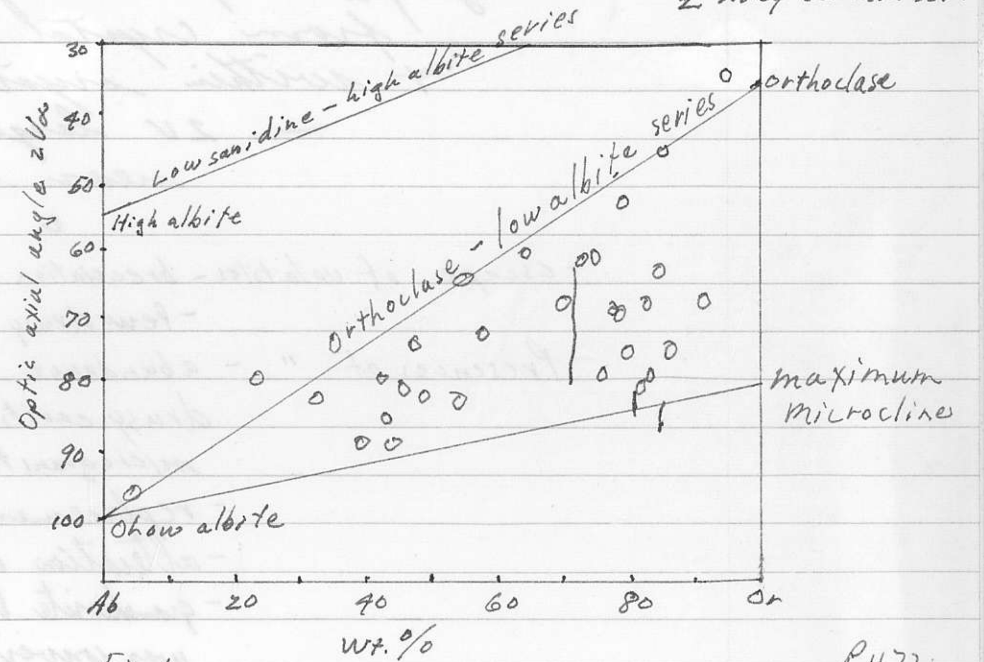


Fig. 1

P1172

mod. Tuttle (1952) - lines represent variation in optic axial angles

Bulk composition of feldspar ∴, include both feld-phases

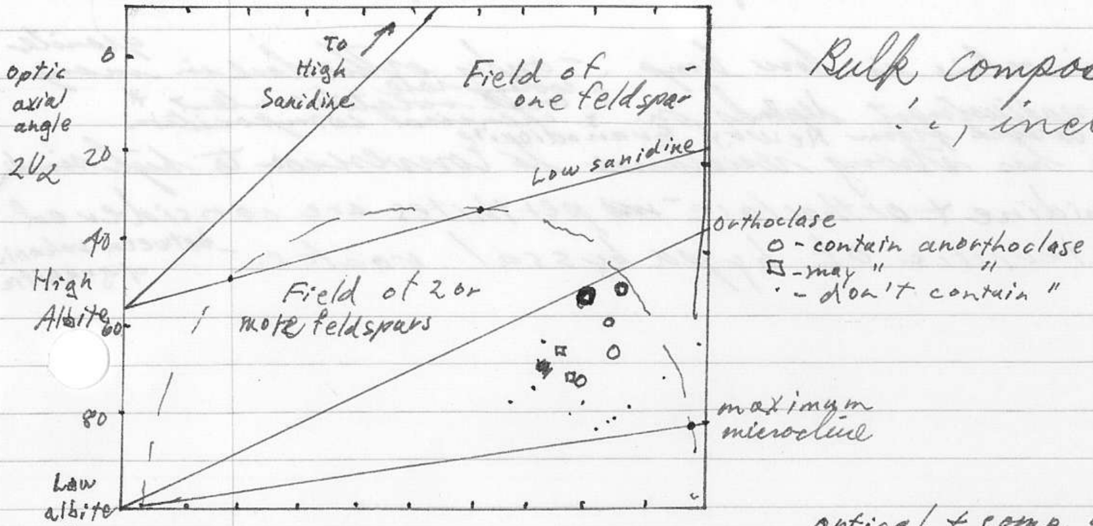


Fig. 5
P1177

optical + comp. correlation of perthitic + non-perthitic feldspars

The Alkali Feldspars VI. Sanidine and Orthoclase Perthites from the Slieve Gullion Area, Northern Ireland

C. H. Emeleus & J. V. Smith Am. Min, Vol. 44, Nov.-Dec 1959 P1187-1218

- local variations in extent of adjustment to the low-temperature assemblages - variations in volatile content

- 2V vary from specimen to spec.
  from crystal to crystal
  + within crystal - sense zoning.
  — 2V larger in turbid areas near exsolved plag.

- escape of volatiles - brecciation (agglomeration) - fracturing of phenocrysts
  - few drusy cavities
- Presences of " - abundance of amphibole, numerous small drusy cavities, leading to the relatively coarse microgranitic & granophyric textures of grdmass
  - replacement of pyroxene & olivine by amphibole
  - alteration of country rocks was marked
  - granodiorite was baked + some of crushed rk. was converted to fine-grained biotite-quartz-plagioclase hornfelses.

- ? if microcline is low temp. - only orthoclase in many granites
- structural readjustment depends on: 1. cooling rate 2. local volatile content * 3. chemical composition
- microcline has strong resistance to conversion to high sanidine → derived from Newry Granodiorite

P1204 - Thus sanidine + orthoclase ~~m~~ perthites are considered characteristic of hypabyssal rocks. - between volcanic & granitic

Min. Mag., March 1954 Goodyear & Duffin. The Identification
P306 of Plagioclase feldspars by the X-Ray powder
method

Good Paper Criticizes Claise (1950) only optical det. claimed accuracy of 1% of composition
didn't recognize high & low
temp forms. only 8 specimens

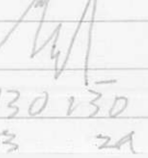
- Gives comp. Amelia Albite

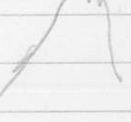
P308 - composition of feldspar can vary considerably
throughout a particular specimen
- ∴ may get spread of compositions from
optical det. (Chayes - R.I.)
- X-ray method - should have representative sample

The Orthoclase - microcline Inversion
W. MacKenzie Jan, 1954, 356

Reported orthoclase with Microcline
- Monoclinic feld. ∥ ext. ∥(010) & multiple twinning
- but ∠ may be just slightly triclinic ∴ not
detectable - sometimes detectable by X-ray
powder
- need single crystal data

Laves (1950) - states that for existence
of pericline & albite
twinning in microcline
- have to crystallize with
monoclinic lattice

~23-24° 2θ - small peak between 130 & $1\bar{3}0$
indicates presents of orthoclase
& broad peak suggests it is monoclinic
eg



but some
microcline

- orthoclase - microperthite
  - limited ordering due to Si + Al atoms

* - monoclinic & triclinic feldspars depend on chemical composition
  - pure $KAlSi_3O_8$ = microcline
    $K(Na)AlSi_3O_8$ = " to ortho.

Transactions volume 211
American Institute of Mining, Metallurgical & Petroleum Engineers

Good Paper but short.

P262 _ Geology of Toquepala, Peru
K. Richard & J. Courtright
- ore in large breccia pipe (angular frag.) rounded frags no ore.
- Original texture of diorite obliterated
  - qtz. - sericite rk.

Nov. 7, /62

J.V. Smith - Min. Mag. March 1956 - pp. 47-67

Prodecure for determining Structural State + Composition of Plag.

① Measure $2\theta(131) - 2\theta(1\bar{3}1)$ for $An_{20}-An_{40}$

② if between An_0 & An_{20} (peristerite region) measured $2\theta(\bar{1}32) - 2\theta(131)$ + several other steps - refer to him if necessary.
$2\theta_{Cu}$ 33.85 ± 0.1

③ If low temp. measure $2\theta(111) - (1\bar{1}1)$ for check

o - Natural plag.
□ - heated " "
X - synthetic "

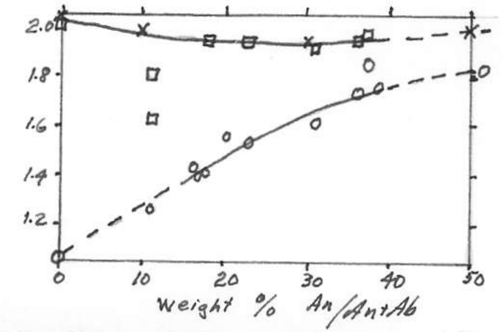


Fig. 3 - Values $2\theta(131) - 2\theta(1\bar{3}1)$ plotted against chemical comp.

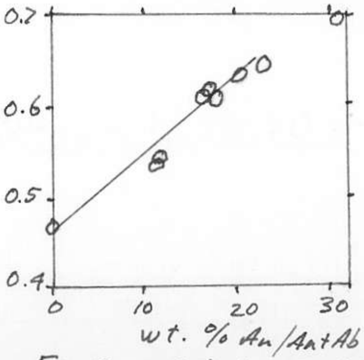


Fig. 5 - $2\theta(111) - 2\theta(1\bar{1}1)$

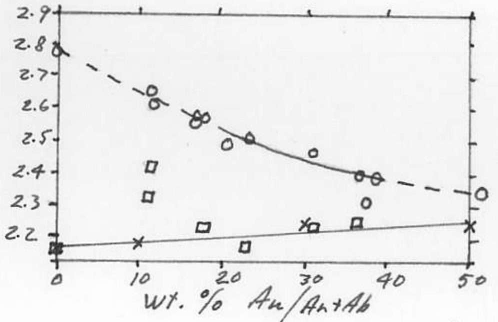


Fig 4. $2\theta(\bar{1}32) - 2\theta(131)$

Origin of Myrmekite - late magmatic Xtllization
- Or & Plag. boundaries - Plag (Na+Ca)-replace Or. - release silica
=vermicular qtz.

Drummond's Thesis - Geol. of the Alice Arm Moly. Prospect.

Bib. Anderson, G. H. (1937) Granitization, Albitization & Related Phenomena in the N. Inyo Range Cal. - Nev.
G. S. A. Bull., vol. 48, no. 1, pp. 1-74.

Bostock's thesis (1956) - Shingle Creek Porph.

Hayes, J. R. & Klugman, M. A. (1959) Feldspar Staining Methods: Jour. Sed. Petr., vol. 29, no. 2, pp 227-232

Spencer, E. (1945) Myrmekite in Graphic Granite & in Vein Perthite: Min. Mag., vol. XXVII, no. 189, pp. 79-98

Campbell (1959
Ec. Geo. vol. 54 no. 8
Torbit Silver
pp. 1461-1470

— // —

Alaskite - a plutonic rk. consisting of orthoclase, microcline, and subordinate quartz, with few or no mafic constituents (maybe plag.) - a leucocratic granite.

Tuttle, O. F. (1952) Optical Studies on Alkali Feldspars: Am. Jour. Sci., Bowen Vol., pp 553-567

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Chap. I Introd.
Location & Accessibility
Previous Work.
History
Nature of the Area
Flora & Fauna
Investigation - field work; 95 T.S. + 100's H.S.; X-ray id.; stain techniques on K-feld. 30 H.S.

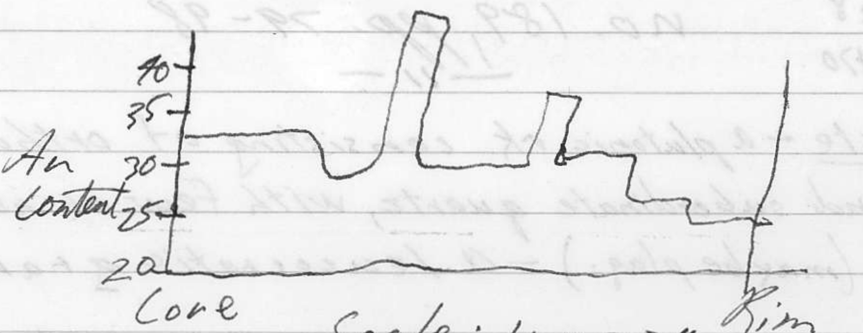
II Regional Geology
structure of the ap. ar. area.

III Geology of the Lime Creek Area.

Method used by H. J. Greenwood
+ R. C. McTaggart (1952)

P56 - zoned plag. pheno. - using a four-axis u.v. stage
- used xtl. ~⊥ (010) — with ?(001) clv. & pericline twinning
- orient until "a" dir. ∥ axis of micro
- ∠ bet. x' (fast ray) + (010) trace was measured for successive zones from the core to the margins of the xtl.

∠ x' (010)	An comp.	width of zone
16.0°	32	0.4 mm.
12.3°	29	0.15 "
24.0 etc	42	0.05 "
		0.4 " etc.



Scale: 1mm = 2"

Curtis (1954) origin of Pyrocl. debris flow.
Can. Inst. of Min & Met. Trans.
Vol. LX, pp 273-289.

For Thesis Outline - Memoir 139-1924 - G.S.C. by C.E. Cairnes

Coquihalla Area - B.C.

Chap. I - Introduction pp. 1 Act., Previous Work, Climate, Fauna
" II - Gen. Char. of District 10 - Top., Relief, Drainage, Glaciation, Terraces [illegible] Industries
" III - Gen. Geology 26 - Reg. Geol. out. - East flank Bath; Geol. Area out; Formations; Struct. Groups
" IV - Structural & Hist. Geol. 120 - Summary of Geol. Events p 130
" V - Economic Geol 131
" VI - Summary & Conclusions 165
Index

Topic The basic interest of the research is a study of the geologic history of the area. There is a large zone of highly metasomatized rocks that contain sporadic, low grade copper and molybdenum mineralization. It is hoped that a study of the history of the area will shed some light on the origin of these deposits.

- The rocks of the mapped area, in general, have undergone extensive mineralogical & often chemical reconstitution since their initial formation.

KENNCO EXPLORATIONS, (WESTERN) LIMITED

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November 23, 1961

Vancouver, B.C.

Thesis

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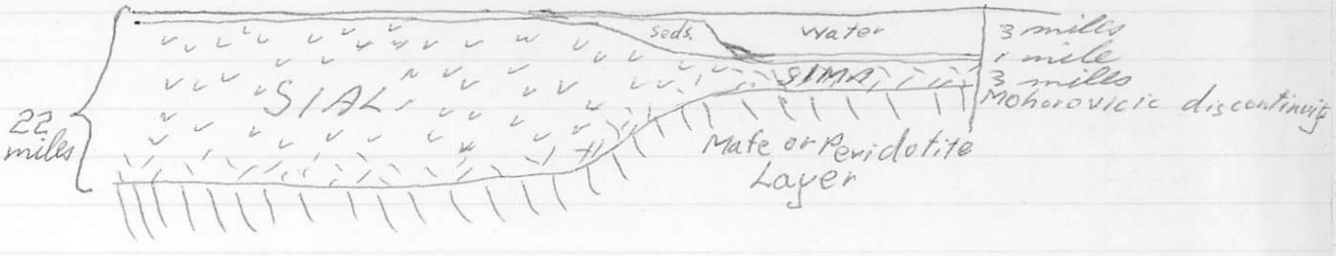
Page No. Note

3 - Sial - Si & Al
- av. density = 2.7
- " " of earth = 5.5
- granitic rocks & assoc. metamorphics compose most of sial - seds. only minor (1-10 miles)

4 - Sima - Si & Ma (magnesium
- basaltic layer of earth's crust
- gradation of Sial to Sima on continents
- av. density = 3.0

- Continents are ~23 miles thick (floating in peridotite layers)

- Mafe (magnesium & iron)



History of Individual Specimens

R.V.K. Dec. 6/62

Photos*

* K-22

1. Crystallization of large K-feld. phenocrysts
2. Rapid crystallization of matrix
3. Replacement of K-feld by albite at step ② or later - may be related to exsolution of albite from K-feld. but definitely replacement. — destruction of mafics ?
4. Fracturing - offset pheno. - motar zones
5. ? Invasion by sol'n. which allowed formation of red microperthite
6. Fracturing
7. Veining by calcite & assuming sulphides here ⟩ from K-23 [mainly]

diss. specularite in red areas.

* K-23

1. Crystallization of large K-feld. phenocrysts & matrix
2. Fracturing - offset crystals & larger fracture
3. Replacement or at least partly replacement & partly intrusion of old porphyry by red granite. - Replacement (& if intrusion) guided by fractures. — destr. of mafics, Silica added
4. Fracturing
5. Veining by calcite (minor Qtz.) and sulphides -pyrite crystallized before chalcopyrite.

Photo? *

K-93

1. Crystallization of white phenocrystals
2. Possible fracturing & cleaving of phenocrysts
3. Replacement by red microperthite (veining & rimming of white pheno.?)
   - crystallization of interstitial, granular quartz — Silica added
   - There is a possibility that "old" white pheno. were picked up by "red" magma but this is unlikely since would have to separate white phenocrysts from old porphyry.

? where chlorite & sericite fit, but probably are late.

K-37

1. Crystallization of White Pheno.
2. Microperthite replacement - rimming & replac. K-feld & plag.
3. Synchronous or following (2.) - silica replacement - veining (no dilation) and matrix replacement. — Silica added
4. Fracturing - one silica veinlet - microscopically displaced
5. Sulphides (predominately chalcopyrite) & chlorite filled fractures

? when sericitization took place

* K-153

1. Crystallization of white K-feld. + plag. feld. as porphyritic syenite

Silica added? 2. *(no obvious fracturing) - "Red" metasomatism - not intense - perhaps because of lack of fracturing
- matics destroyed
  - Or possibly fracturing or stresses are related to the metasomatic activity.
  - red rims on K-feld. + pink microp. in matrix
  - Qtz. crystallization in matrix.
- "Red" attack was not observed as being governed by fractures. Rock is very vuggy & perhaps rock was just completely "soaked."

3. Exact order is not known.
- sericitization of plag. - white to green color
  - claying of " (argillic alt. - only minor)

possibly this order {
- formation of Apatite + sphene
- " of ore
- " of chlorite

Perhaps * for color & matics K-187

1. Crystallization of Sy. Porph.
2. *(no obvious fracturing)
3. Slight metasomatism (perhaps thru. vugs.)
   - a. addition of some pink K-feld. (~20% may involve recrystallization)
   - b. minor silica may have been introduced
   - c. Hb. was partly destroyed - poikilitic (*not chloritized) crystals
     - K-feld. & plag. replace it.
   - d. clear plag.? added (definite low(+) relief)
   - some Sphene & Apatite formed - replace Hb.
3. Lower temperature hydrothermal activity,
   Epidote, (latest) carbonate, sericite, chlorite & magnetite formed
   - Total ~5% of rock.

K-196

1. Crystallization of Sy. Porph.

Silica added 2. *(no fracturing) High temp. metasomatism - microper. + Qtz. added
- replacement + veins in plag.

Silica added + Fe Mg. 3. Low temp. metasomatism
- a Qtz, sericite, + carbonate
- b pyrite -> chalco.
- c chlorite - veins rock. + sulphides

K-238

1. Crystallization of plag. & Hb.
2. " " Qtz. & mymekite - possible by replacement.
3. Chloritic & to a lesser extent calcite & sericite? alteration

K-288

1. Crystallization of k-feld. & plagioclase - probably as white feld.
2. High Temp. Metasomatism

Silica added

    a. bordering, forming new crystals, & replacing by pink microp
    b. crystallization of interstitial Qtz.
3. Low temp. metasomatism -
    - chlorite, calcite, sericite?, ore minerals & perhaps some Quartz formed.

④ Nov. 26/62

K-153 continued

⑲ relatively large microperthite crystal - center slide - bleb ex. all. & plag. cryst.
12°N 8°E not suitable

⑳ same as ⑰ & ⑱ 4°N ~~46°W~~ 47°E ? $V_x = 29°$ $V_x \simeq 35°$ $2V_x = 64°$

㉑ small, albite twinned, interstitial plag. grain
12°S 41°E $V_z = 39°$ $2V_x = 102°$ poor

Rittman zone
40° 315.7 / 304.3 / 11.4   324.4 / 316.7 / 7.7   ~~325~~   max. ext. = 9.9°
30° 325.3   An12 or An27
20° 326.3 326.6   by 2V
10° 326.2
0° 324.5 / 323.5

㉒ Core of gutted-out, large plag. crystal - possibly albitized
12°S 23°W fair $V_x = 47\frac{1}{2}°$ $2V_x = 95°$
50° 299.7
Ritt. zone 40° 297.2 max ext. ~8°
30° 299.2 An13 or An25
by 2V

㉓ Edge of moderate sized "gutted" plag. (small clear patch)
$1\frac{1}{2}$°N 14°W
$V_x = 46\frac{1}{2}°$ $2V_x = 91\frac{1}{2}$
50° 323.4 $V_x = 45°$ excellent
30° 325 / 324.5
10° 326.8 max. ext. ≃10° An27 or An10

㉔ moderate sized - least altered crystal in section only scattered sericite?
38°S 39°E $V_x = 45\frac{1}{2}°$ $2V_x = 91°$
Rittman zone doesn't fit L.T. 2V curves
max. ext. ~14° An4 or 30

Corrected value for $2V_x \simeq 89\frac{1}{2}$

largest k-feld. crystals not measured

- usually microp. k-feld.

K-187 - largest k-feld. crystals don't contain much microperthitic albite
- plag. is generally not as highly altered as K-153

① Center largest k-feld. crystal (oscillatory zoning) - perthitic border
- little ex. albite (unusually clear)

122° 1°S 26°E — not suitable

② other twin member - core - mod. ex. alb.

161½° 25°S 18°E $V_z = 50^\circ$ $\therefore 2V_x = 80^\circ$

③ Small, twinned, perthitic crystal near large crystal

307½ 0° 31°W not suitable

④ Small to mod. k-feld. crystal - ex. albite

320° 10°S 38°W $V_z = 55^\circ$ $\therefore 2V_x = 70^\circ$

⑤ same as ④

2° 42½°S ~~33°W~~ 57½°E $V_x = 41^\circ$ $2V_x = 82^\circ$

⑥ mod. large crystal at edge slide - ex. & incl. = plag. ? zoned

52° 8½°N 29°W $V_Z = 49^\circ$ $2V_x = 82^\circ$

⑦ mod. sized crystal - untwinned - near large crystal - ex. alb.

108° 6°S 25°E $V_z = 48\frac{1}{2}^\circ$ $2V_x = 83^\circ$

⑧ same ⑦ ex. alb. marks previous zoning

3° 27½°S ~~25°E~~ 60°W $V_x = 29\frac{1}{2}^\circ$? $2V_x = 59^\circ$

⑨ same ⑦ - much ex. alb.

303° 21°N ~~36°W~~ 54½°E $V_x = 35^\circ$ $2V_x = 70^\circ$

⑩ Plag. - unaltered edge of small to mod., gutted, crystal. near big xtl.

259° 4°S 14°W $V_x = 49$ $V_x = 47$

$2V_x = 96^\circ$ also $V_x \cong 43$ & 45°

Rittman zone. $2V_x = 88^\circ$ on complimentary twin ???

max. ext. = 12½° An_7 or An_{28}

⑪ Mod. sized, corroded plag.

113½° 15°S 6°W $V_x = 45$ $V_x = 46$ $2V_x = 91^\circ$

Rittman zone

max. ext. ≃ 15½° An_0 or An_{32}

2V is inconclusive

⑫ Small grain - not too highly altered - intrst.

108½ 21°N 38½°E $V_x = 47$ $2V_x = 94^\circ$

Rittman zone

max. ext. ≃ 19° An_0 or An_{36}

2V is inconcl.

① Nov. /62

Results of 2V determinations

K-23 ① microperthite – coarse, twinned albite strings
- ext. is poor because of many exsolved minute blebs

poor
V = 36° – x is acute bis. ∴ (–)
2V = 72°

② interstitial grain cloudy – only small % ex. albite
not suitable
- ext I.V. = 290.5 284 final 12°
" I.EW. = 12°
" N.S. = 30°

③ much ex. plag. small inter.
ext. in general is irregular throughout crystal
42° V = 58-60° fair z obtuse bis ie ± x.
30°
2V = 118°
2V = 62°

④ 30° small inter V = 32° ∴ 2V = 74° (–)
49°

⑤ medium to large grain coarse albite strings
162° 18° 25°(–)
good V = 360 / 305 / 55° to z ✓
2V = 110° + 70°

2V = 72°
= 62°
= 74°
= 70°
= 77
= 80°
= 61°
= 78°

⑥ med. to large – ex. albite – opt. axis ~⊥
40° 34° 11° 2V = 77°
good. V = 38½°

⑦ similar ⑤ ~~6~~ – two clv.
160° 11° 20+° V = 50° 2V = 100°
good z obtuse bis. 2V = 80°

⑧ large crystal – area test less albite than rest Xtl.
blotchy ext.
161° 36° 31° V = 30½
good. 2V = 61°

** all plag. in slide is exsolved

⑨ blotchy ex. alb., fairly regular ext., 2 clv.
176 22½ 23° V = 51° 2V = 102°
good z obtuse bis. 2V = 78°

Rittman zone on small plag. Xtl.
⊥a = 15° x' acute <
↑ note is wrong
An_0 or An_{3031}

for 2V 129° 8° 40°
V = 57° 2V = 114 2V = 66°
x is obtuse bis. ∴ (+)

K-22 - mainly big xtls. with only a few interst. microp. grains (red xtls.) - very blotchy & irregular ext.
- only ex. plag. in small xtls. shear

*must be ~~separa~~ individual

① 

ext. is in thin // rows.

- near
- small patch at edge of large crystal
- different ext. than main xtl.
- only minor fine ex. plag.

172° 2° 11°
v. good V = 34° & V = 37° ∴ 2V = 71°
x is acute bis., ∴ (−)

② 181½° 2½° 35° large xtl.
V = 47° z - obtuse bis.
2V = 94° 2V = 86°

2V = 71° good
= 86
= 76°
= 71°
= 80°

③ 200½° 8° 30° large. xtl.
good V = 52 z = obt. bis.
2V = 104
2V = 76°

not suitable ④ inter. to larger xtl.
192½° 2½°.

⑤ large xtl. of crystal agg.
174 3° 26° V = 54½ near end of rotation ∴ poor
2V = 109°

2V = 71°

not suitable ⑥ Center of large xtl.
220½ 9° 28°

not suitable ⑦ large crystal
124½ 37 24

⑧ intermediate
224° 12° 30°
V = 50°
2V = 80°

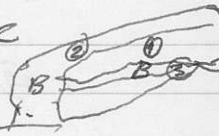
②

Nov. 23/62

K-93 – K-feld. crystals old white center – red microperthitic crystals in matrix, veins, and as borders.
– Plag. all is altered to sericite &/or clay minerals
– "some" xtls. have the red borders

all same crystal.

① Interior of large, elongate crystal at edge



microp.
I.V. 335° I.E.W. 9½° NS. 10½
$V = 44$ & $V = 44$
good. $2V_z = 88^\circ$ ∴ $2V_x = 92^\circ$

Handle
N
W E
S

② microper border. – sector ext.
225 9°N 22°W $V_z = 48^\circ$ ∴ $2V_x = 84^\circ$

This was poorer reading than

③ Veinlet
147° 8°S 14°E $V_z = 49^\circ$ ∴ $2V_x = 82^\circ$

④ Same center crystal – not very good because of fine sector twinning
140° 8½°S 15°E
$V_z = 38^\circ$ ∴ $2V_x =$ ~~104~~ 104°

⑤ Smaller red crystal – much exsolved alb.
– undulatory ext.
not suitable 79 11½°N ~~37°E (poor)~~ 49½W

⑥ Small red grain – much exsolved albite
162½ 3°N 7½°W
poor? { $V_z = 97^\circ$ / $U = 754^\circ$ } 100 $V_x = 79^\circ$

⑦ S.R. grain – ex. alb.
29½ 10½°S 38°E 52°W ? $V_x = 18^\circ$ $= 2V_x = 36^\circ$

⑧ same as ⑥ & ⑦
poor 227½ 33°S 43°E ? $V_x = 31^\circ$ $2V_x = 62^\circ$

⑨ same as 6, 7 & 8
307½ 7½°S 14°W $V_z = 50^\circ$ ∴ $2V_x = 80^\circ$
fair but some sector ext.

⑩ same as 6 etc.
266½ 8°N 15°E ? $V_z = 97^\circ$ $2V_z = 96^\circ$ or 101
$V_z = 701 \simeq 54^\circ$
$2V_x = 79^\circ$

K-153

Nov. 25/62

- plag. is highly altered
- k-feld. is zoned & microperthitic - not too altered

① center of largest zoned (reentrant) k-feld xtl.
198½° 1°N 25°E not suitable

② border same xtl. ~ $2V_z > 105°$ same orientation as core
also not suitable

③ reasonable large interstitial microperthitic grain
162½° 12½°N 42°W

④ Core of large k-feld crystal - microperthitic

190° 21½°N good 32°E
$V_z = 53°$, $\therefore 2V_x = 74°$

⑤ Border of same crystal as ④
326° 46°N too steep of incl. I.E.W. 34°E ? $V_x = 31°$
13½°S 28°W good $V_z = 52°$ $2V_x = 78°$

⑥ k-feld. - microperthitic crystal bordering crystal ④ ~~&~~⑤
346° ~~N~~ 19°S 8½°W poor $V_z = 59°$ $2V_x = 62°$

⑦ ④ repeated
36° 15½°S 30°W good $V_z = 53°$ 307 or 307½ $\therefore 2V_x = 74°$

⑧ ⑤ repeated
31½ 11½°S 30½°W good $V_z = 54°$ $\therefore 2V_x = 72°$

⑨ Core of last of large k-feld. crystals (coarse plag. inclusions)
334° 42°S 27°W $2V_z = 55°$ $\therefore 2V_x = 70°$

⑩ Border of ⑨
20°N 39½°E $V_x = 35°$ $\therefore 2V_x = 70°$

⑪ Interstitial, microperthitic k-feld. grain
74° 30½°N ~~33°E~~ 53°W poor $V_x = 30°$ $\therefore 2V_x = 60°$

⑫ same as ⑪ - lath shaped - twinned
121½ 35°S ~~27½°W~~ 62°E poor $V_x = 33°$ $2V_x = 66°$

⑬ same as ⑫ - slightly? small grain
~262° 11½°S 10°E not suitable

⑭ other ½ of ⑬ Carlsbad twin
~257° 15°S ~~24°W~~ 59°E " "

⑮ same as ⑪ i.e. sound, anhedral grain
163° 40°S 22°W not suitable

⑯ same as ⑮ & ⑪
148° ~~3½°W~~ 1°S 25°E " "

⑰ same as ⑯ etc. - very small grain - microperthitic
46°S 28°W good $V_z = 59½°$ $\therefore 2V_x = 61°$

⑱ exactly same as 17 - 19°N 29°E $V_x = 32$ $\therefore 2V_x = 64°$

Nov. 26/62

K-211 – only plag. in fine matrix

① large crystal – dusty center – partly altered

261½ 3°N 30°W $V_x = 47\frac{1}{2}$ other V_x probably $\simeq 49\frac{5}{8}$

Rittmann zone max. ext. ≃12° An⑫ or 19 $2V_x \simeq 96° - 97°$

Ang by Enamon's curve.

② mod. sized – euhedral, equant, altered grain – untwinned

251° 3°N 19°E not suitable

③ small 2 unit alb.-twinned crystal

283½° 0° 14°W $V_x = 48$ & $V_x = 48$ ∴ $2V_x = 96°$ good

Rittmann zone max. ext. ≃14°

using McT.'s curve (An₉) or An 31

right on

④ mod. sized – edge of slide – 2 unit alb. twin – & small slips

243½° 3°N 28½°E not suitable

R. Z. max. ≃ 8°

⑤ small crystal – pericline twinned xtl. at end.

326° 16°N 7°E $V_x = 49$ & 49(½°?) $2V_x = 98°$ good

Ritt. Z. max. ext. 11½ – 12°

by McT.'s – An⑫ or 28

K-112 – plag. is "ghosty" – highly altered – relic zoning – complex twinning – no K-feld. similar K-114 & not unlike K-211

① small crystal – irregularly twinned (alb. t.)

160° 15°S 18°E $V_x = 47°$ ∴ $2V_x = 94°$

Ritt. Z. max. ext. ≃22°

McT.'s

poor An₀ An40?

② large complexly twinned crystal.

20½ 3°S 31°W $V_x = 49°$ poor $2V_x = 98°$

max ext. = 23° An㊶?

③ largest crystal in slide (over ½") very corroded.

82½° 35°S ~~38°E~~ 46°W $V_z = 39\frac{1}{2}$ $V_z = 103$

④ longest (2nd largest) crystal in slide – faint alb. & marked per. twinning

32½° 11°N 35°E $V_z = 45°$ ∴ $2V_x = 90°$

alb. ≃ hor.

[K-114] - very similar to K-112.

① mod. sized, very corroded, equant, alb. (uniform) twinning

134° 4°N 46°W $2V_x > 94°$ ≃ 96°–100°

Ritt. zone – max. ext. ≃ 8° = An_{14}; or 26

② mod. sized. – alb. & per. twinning – near corner

66° $12\frac{1}{2}$°S 15°W $V_x = 49°$ $2V_x = 98°$

R.Z. – max. ext. ≃ 13° M.cT's. An_{10}; or An_{30}

ext. (per) ≃ 11°

③ Small xtl. – 2 alb. individual

128° 10°S 46°W $V_x = 45$ – very poor $2V_x = 90°$

R.Z. – max ext. ≃ 11° An⑫ or 27

④ mod. sized, equant.

$12\frac{1}{2}$° 13°N 19°E $V_x = 49$ $2V_x = 98°$

alb. twins ~ hor.

May '62 Powders (Mainly Feldspars) - for X-Ray, R.I. + ~~Spect.~~ Diff. R.U.K. important

2 ✓ K-22 - A Large white Phenocrysts A + $KBrO_3$ mount 2 oscillations may 23rd

B Reddish (microper.) Borders B - difficult to obtain reliable material → + $KBrO_3$ - relatively clean sample - no visible qtz. 1 osc. Ab Peaks - 3 oscil. Or Peak by accident

+ K-22 - sample of everything

→ + $KBrO_3$ - sample had visible qtz.. contamination 1 osc. - qtz. & K-feld Peaks merge free from qtz

2 K-23 - B sample of (microper.) reddish feld. B - difficult to get sample

✓ - A large ~~whitish~~-gray phen. + $KBrO_3$ mount 1½ oscillations May 23rd

K23 A + Qtz. → 1 oscill May 30th 1 run for plag.

1½ oscill ← worked well after this added $KBrO_3$

May 30th I think clean material more plag. than K-feld.

2 K-93 - A white phenocrysts ① Or + Qtz ② & Plag. runs. 131 - 1̄31 - 1 oscillation 1 osc. May 30th

- B red borders + $KBrO_3$ (Borders not intertitial grains) sample not very clean probably some qts. 2 oscillations May 23/62 + $KBrO_3$

K-112 - Large white feldspar xtls. ① Or — ~~An + Ab~~ ② An — Ab ← 1 oscillation 1 osc. May 30th

3 K-114 - " " " " ~~① Or — An + Ab~~ ~~② An — Ab~~ Or Run 1 osc. Just Plag Peak. Anyhow added $KBrO_3$ after this powder

— + $KBrO_3$ 2 oscillations → for Or + Ab.

1 osc. for plag. but $KBrO_3$ interferes

K-153 - clay alt. of Plag. - get more when want film A

- A inner plag. zone. A 1½ oscillations 1 ½

✓ B outer plag. zone (+ small plag. xtls.)

C (Centre) whole of Large white K-feld. xtl. + $KBrO_3$ 3 oscillations

D Smaller, pink K-feld xtls. = ? border of Large xtl

✓ 3 Mineral separation ① Plag → 2 oscillations

② K-feld. (small pink grains) + $KBrO_3$ → 2½ oscill

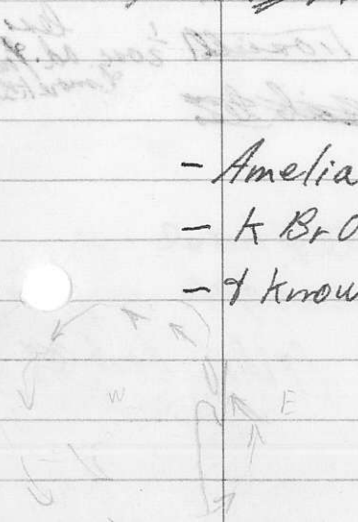
3 K-187 - A green crystals - plag. ① Plag. min. seps. 2 oscillations

✓ 3 B pink crystals - K-feld. ② K-feld. + $KBrO_3$ 3 oscillations

✓ 3 K-211 A Mineral Plag. - broad ragged peaks. 2 oscillations

- Amelia Albite
- $KBrO_3$
- + known K-feld low temp.

} run 3 standards ~15° - 40° 2θ + the 3 mixed to see effects.



X-Ray Diffractometer

AM. Min. 1956 Smith + Yoder Vol. 91 P632
oscillate bet. - 2θ 29 + 32

$1\bar{3}1$ ~29.3 to 30° 131 31.2° to 31.5°

		d Å	I		2θ
Adularia	(Or.9-482)	6.44 1.37	60 70	(020)	13.25
$KBrO_3$ (7-242)		4.39 to 0.7895	60	(101)	20.2
Amelia Albite 98.2% Ab 1.8% Or		6.39 to 1.785_{α_1}	20	(001)	13.85 51.3

98.0 Ab
0.4 An
1.6 Or

Min. Mag 31 47 (1956)
Smith + Yoder

Min. Mag
March. 1958
Goodyear
& Duffin
P306

June 4th/62 — Ran Standards

Description of Sample

1. $KBrO_3$ (15°-37° 2θ) 1° 2θ = 1 chart div. White Powder Reagent grade (very pure)
2. Amelia Albite (") " milky Coarse, fresh, white crystals 2" dia
3. Pikes Peak Microcline " " amazonstone Small chips off large crystal some chips have minor Hydrous Fe Oxide coating
4. St. Gothard Switzerland Adularia ( ) " milky ~~Coarse~~ coarse, fresh, white crystals

Pikes Peak Micro. + $KBrO_3$ osc. 20.0-22.8 2θ ~~1 oscill~~
Adularia + $KBrO_3$ osc. 20.0-23.0° 2θ ~~1 oscill~~ ½ osc. less ad. powder & more $KBrO_3$
Amelia Alb. 29-32.0° 2θ ~~1 oscill~~ ~~½ oscill less~~
" " + $KBrO_3$ 29.-32° 2θ ½ oscill.

as separate phase.
P357 Min Mag. 1954 est. 2% Ab optically microps.
∴ Or 95.6 Ab 3.4 An 1.0 (Pikes Peak Xl amazonstone)
93.6 5.4 1.0

Nov. 1/62

X-ray Results – Sheet 2

	Specimen No. & Description	No. Oscillations	Difference Degrees 2θ	Or – An+Ab %	Ab – An %	
Large white feld. xtls. relatively unaltered k-feld. in highly alt. rk!	⑪ K-114 + $KBrO_3$ 2 feld. phases but almost negilible albite. 1 oscill. ($131-1\bar{3}1$ plag.) but $KBrO_3$ interference	2	poor Ab good 0.78 1.85 0.78 1.85 0.79 1.82 0.78 1.85	$Or_{94} Ab_6$ Ab_{100} $Or_{95} Ab_5$ Ab_{100} " $Or_{95} Ab_5$ Ab_{100}		
Inner zone in plag. crystal	⑫ K-153 A split (zoned) peaks	1 1/2 ~6 zones to	fair 1.35° – av. $\bar{1}31$ main pk 1.11 1.36° – av 1.08 1.35° – av 1.18	~~– $An_{13} Ab_{87}$ –~~ ~~– $An_{14} Ab_{86}$~~ ~~$An_{15} Ab_{85}$ –~~	assume low temp $An_{13} Ab_{87}$ An_2 $An_{14} Ab_{86}$ An_0 $An_{13} Ab_{87}$ An_6	— main peak zoned to albite
All Plag. (mineral sep)	⑬ K-153 ① broad, ragged peaks due to zoning but a mean was attempted in all cases	2	av. fair top 1.20° 1.34° 1.23° 1.24° 1.24°		assume low temp $Ab_{93} An_7$ $Ab_{87} An_{13}$ $Ab_{92} An_8$ $Ab_{92} An_8$ $Ab_{92} An_8$	
K-feld. (min. sep.) small pink grains	⑭ K-153 ② + $KBrO_3$ 2 feldspar phases measured higher on peak →	2 1/2	0.78° good 1.88° 0.78° 1.87° 0.78° 1.87° 0.74° 1.85° 0.78° 1.87°	$Or_{95} Ab_5$ Ab_{100} $Or_{95} Ab_5$ Ab_{100} $Or_{95} Ab_5$ Ab_{100} $Or_{98} Ab_2$ Ab_{100} $Or_{95} Ab_5$ Ab_{100}		
whole of large white pheno. – Pink zone at border.	⑮ K-153 E + $KBrO_3$ Intensities suggest more microcline than albite 2 phases pure albite & Max microcline	3 Ab. 1.83 Or. 0.87 peaks	Ab peak good 0.85 1.82 0.87 0.85 1.80 0.87 1.84 0.85 1.83	$Or_{87} Ab_{13}$ $Ab_{100} Or_0$ $Or_{87} Ab_{13}$ $Or_{88} Ab_{12}$ $Ab_{100} Or_0$ $Or_{87} Ab_{13}$ $Or_{87} Ab_{13}$ $Or_{88} Ab_{12}$		
Plag. (min. sep.) green crystals	⑯ K-187 A broad, ragged peaks (zoned)	2	zoned to 1.30 1.15 fair 1.22 av. - - - zoned to 1.30 1.1 1.21 av. - - - zoned to 1.35 1.08 1.22 av. - - - zoned to 1.36 1.12 1.25 av. - - -		assume L.T. $An_4 - An_{10}$ An_7 $An_1 - An_{10}$ An_7 $An_{14} - An_0$ An_7 An_1 $Ab_{99} - An_{15}$ An_9	
* for thesis K-feld. (min. sep.) Pink crystals.	⑰ K-187 B ② + $KBrO_3$ expand Slightly more K-feld than Plag 2 phases	3	0.75° good 1.82° 0.75° 1.82° 0.74° 1.82° 0.74° 1.84° 0.74° 1.82° 0.74° 1.83°	$Or_{97} Ab_3$ $Ab_{100} Or_0$ $Or_{97} Ab_3$ $Ab_{100} Or_0$ $Or_{98} Ab_2$ $Ab_{100} Or_0$ $Or_{98} Ab_2$ $Ab_{100} Or_0$ $Or_{98} Ab_2$ $Ab_{100} Or_0$ $Or_{98} Ab_2$ $Ab_{100} Or_0$		
Plag. (min. sep.)	⑱ K-211 broad, ragged peaks (zoning) microcline interference. $1\bar{3}1$ is very broad & ragged	2	poor 1.37 av 1.37 av 1.37 av 1.42 av 1.50 This one $1\bar{3}1$ is 2 distinct peaks – 1.50 would closer a correct answer	– it's obvious that av. is not accurate since 131 plag. doesn't = $1\bar{3}1$ micro.	assume L.T. An_{15} An_{15} An_{15} An_{17} An_{20}	

Oct. 30/62

X-ray Analyses Results

	Specimen No. & Description	No. Oscillations	Degrees 2θ	Or/An+Ab %	Ab/An %	Actual Recorded Comp.
Check 2? small % exsolved Albite	① Pike's Peak Microcline –	1 oscill.	– 0.82 poss. 0.79 – 0.82	90–92 % Or		95.6 % Or 3.4 % Ab 1.0 % An 2% albite 5.4%
	② St. Gotthard Adularia	1	0.34° poor det. better best Ad. 0.77° Peak Poor	✓ ~97% Or		89.74 % Or 9.18 % Ab .10 % Ca .21 % Ba
	③ Amelia Albite – Pure	1	1.03° (1.08 low on pkg 1.07) 1.00°		1.06° Δ2θ 100% Ab " "	98.0% – 98.2% Ab 1.6 % – 1.8% Or 0.4 % – An
	– +KBrO$_3$	½	1.07°		" "	
	④ K-22B (May 16/62 – run with Qtz.)	½	1.2 Med. on Peak fair		if low temp ~ An$_7$ Ab$_{93}$	
Large white Phenocrysts ↑ reverse ↓	+KBrO$_3$ 2 feld phases slightly more K-feld. than Na- "	1 Ab phase ③ Or " ~1 at 1/2 div. = 1/20	0.77° 0.77° 0.77° 1.86° 0.76° 1.86°		Or$_{95}$ Ab$_5$ Or$_{95}$ Ab$_5$ Or$_{95}$ Ab$_5$ Ab$_{100}$ Or$_{96}$ Ab$_4$ Ab$_{100}$	
Reddish microperthitic Borders	⑤ K-22A +KBrO$_3$ – 2 feld. phases – only minor albite	2	0.78° good 1.85° 0.77° 1.82 0.77° 1.81° 0.79° 1.85°		Or$_{95}$ Ab$_5$ Ab$_{100}$ Or$_0$ Or$_{95}$ Ab$_5$ Ab$_{100}$ Or$_0$ Or$_{95}$ Ab$_5$ Ab$_{100}$ Or$_0$ Or$_{95}$ Ab$_5$ Ab$_{100}$ Or$_0$	
131 micro. = 131 plag.	⑥ K-23A +Qtz. for plag 131 – 29.5 Microcline (interference by ~~unknown~~ phase (K-feld?)	1	okay estimates 1.14 1.17	high Or content indicated	assume low temp Ab$_{97}$ Ab$_{95}$	
Large whitish Gray phenocrysts	+KBrO$_3$ micro, broad split ∴ zoned plag. phase is negligible (trace)	1½	0.76° good 0.76° 0.76°		Or$_{96}$ Ab$_4$ " " " "	
Reddish microperthic Borders & Separate xtls.	⑦ K-23B 2 feld. phase +KBrO$_3$ ~2/1 = Or/Ab Qtz. Contamination zoned K-feld?	~~2~~ 1	0.75 fair 1.82 0.74 1.85		Or$_{97}$ Ab$_3$ Ab$_{100}$ Or$_{98}$ Ab$_2$ Ab$_{100}$	
(over) White phenocrysts	⑧ K-93A Plag. & K-feld phases K-feld. – zoned? split peak. +KBrO$_3$ intensities indicate more plag. than K-feld.	K-feld. phases 1½	0.70 good 0.76 av. 0.79 1.82 0.75 av. 1.82 0.75 av. 1.82		Or$_{100}$ Ab$_0$ Or$_{98}$ Ab$_2$ Or$_{93}$ Ab$_7$ Or$_0$ Ab$_{100}$ Or$_{97}$ Ab$_3$ Or$_0$ Ab$_{100}$ Or$_{97}$ Ab$_3$ Or$_0$ Ab$_{100}$	
Okay because can't be less than 1/10	for plag. – broad ragged peaks (microcline) microcline interference 131 micro. = 131 plag.	1	1.12° 1.14°		Low T. Ab$_{99}$ Ab$_{98}$	
Red borders	⑨ K-93B +KBrO$_3$ 2 feld. phases considerable albite & microcline readings taken high on peaks	2	0.75° good 1.82° 0.76° 1.83° 0.75° 1.86° 0.75° 1.86°		Or$_{97}$ Ab$_3$ Ab$_{100}$ Or$_{96}$ Ab$_4$ etc.	
(over) Large white feld. crystals	⑩ K-112 ① +KBrO$_3$	1	1.78 good 1.79	Or$_1$ Ab+An$_{99}$ Or$_0$ Ab+An$_{100}$		✓ check calcite lines
May 23rd	1 unknown strong 29.45 peak ② for plag. broad ragged (zoned) peaks check comp. optically	1	poor to fair 1.55 1.58		assume L.T. An 22.5 An 24	~ probably okay

May 30th check comp. optically

✓ large sheet

K-112 1 oscill 2 $\Delta 2\theta$ 1.63° assume low temp. An_{27}

similar to ⑩ ② other side plag. $\bar{1}31$ very broad 1.59° An_{29}

broad, ragged peaks (zoning)

1 strong unknown peak 29.5

- sericite
- musc.
- epid, etc.

---

⑧ K-93A 1 oscill. $\Delta 2\theta$ assume low temp.

1.1 An_0 Ab_{100}

plag 1.09 An_0 Ab_{100}

no Qtz. or $KBrO_3$

zoned

probably okay since albite is indicated but much k-feld. + only a very little plag.

- 131 plag. + k-feld. overlap so always some interference error.

Corrected $2V_x$'s for Feldspars

R.V.K. Jan. 63

⑤

** All k-feld. Perthitic to some extent

old large crystal is now crystal aggregate

K-22

V's 34 & 37 $2V_x = 71°$ good $\boxed{A}$

Doubled $2V_x = 86°$ A

" $2V_x = 76°$ A

Poor " $2V_x = 71°$ A

$2V_x = 80°$ A to B

K-23

all $2V_x = 72°$ $\boxed{B}$ all poor

Doubled $2V_x = 62°$ B

$2V_x = 73°$ B

$= 70°$

$= 76°$

good $= 80°$

" $= 61°$

" $= 78°$

K-23 **Plag.** all exsolved **

$- \angle a = 15°$

$2V_z = 68°$ Doubled

$2V_x = 112°$ x = obtuse bi. (+)

$\boxed{An_0}$ by $2V_x$ & ext. not An_{30-31}

K 93 A

? if correct. poor $2V_x = 104°$ Doubled

good $2V_x = 92°$ "

same xtl.

K 93 B Red.

doubled $2V_x = 84°$

$2V_x = 82°$ " veinlet. good $V = 59$, $V = 47°$

$2V_x = 79°$ poor

$= 36°$ "

$= 61°$ "

$= 80°$ "

$= 79°$ $V = 47°$ $V = 54?°$

K-112 - high altered plag. * No k-feld.

$2V_x = 93°$ Doubled → max. ext. ≃ 22° poor An_0 or An_{40}?

not antiperthitic

$2V_x = 98°$ " poor → " ". ≃ 23° An_{41}?

$2V_x = 79°$

$2V_x = 89°$

K-114 - same K-112

$2V_x \simeq 96°-99°$ very poor max. ext. ≃ 8° - An_{11} or An_{26}

— $2V_x = 98$ doubled " " ≃ 13° (serial. ≃ 11°) - An_{10} or An_{30}

$2V_x \simeq 90$ very poor " " " ≃ 11° - An_{12} or 27

use. — $2V_x = 98°$ "

only plag. **K-211** -

$2V_x = 96°-97°$ doubled good - max. ext. ≃ 12° An_{12} or 19 (8 Emmons)

$2V_x = 96°$ $V_x = 48$ $V_x = 48$ " - " " ≃ 14° An_9 or 31

$2V_x = 98$ $V_x = 49$ $V_x = 49$ " - " " ≃ $11\frac{1}{2}-12°$ An_{12} or 28

- " " ≃ 8° An_{14} or 26

Pink **K-153②**

good $2V_x = 79°$ Doubled — Border core ? same xtl.

$2V_x = 62°$ " poor (repeat)

$2V_x = 73°$ " good

$2V_x = 69°$ "

$2V_x = 59-60°$ " poor

$= 65°$ " "

$= 62°$ " good

$= 64°$ " "

$V = 29$ $V = 35$ $2V = 64°$ "

large white? **K-153C**

$2V_x = 75°$ Doubled good

~~$2V_x = 62°$ " poor~~

$2V_x = 75°$ (repeat)

$2V_x = 71°$ double good

Plag. 153

core or inner zone **K-153 A**

$2V_x = 95°$ doubled fair

max. ext. ~ 8°

An_{13} or An_{25}°

all plag. min. sep. **K-153①**

$2V_x = 102$ poor double

max. ext. ⊥(010) = 9.9

An_{12} or An_{27} by 2V.

large? inner core?

$V = 46\frac{1}{2}$ $V = 46°$ $2V_x = 91\frac{1}{2}$ excellent

max. ext ≃ 10°

An_{10} or An_{27}

$2V_x = 89\frac{1}{2}°$

max. ext ~ 14°

An_9 or 30 ??

Pink K. feld **K-187②**

Doubled $2V_x = 80°$ large xtl.

" $2V_x = 71°$ mod. to small

" $2V_x = 80°$ "

" $2V_x = 82°$ mod. large

" $2V_x = 83°$ mod.

" $2V_x = 69°$?? "

$2V_x = 70°$ "

Green plag **K-187A**

$V_x = 49$ $V_x = 47$ $2V_x = 96$ V_x 43 & 45 $2V_x = 88$

max. ext. = $12\frac{1}{2}°$

An_7 or An_{28}

$V_x = 45$ & 46 = $2V_x = 91°$

max. ext. ≃ $15\frac{1}{2}°$

An_0 or An_{32}

$2V_x = 93°-94°$ double

m. ext. = 19° An_0 or An_{36}

Determination of Plagioclase with the Four-Axis Universal Stage. F. J. Turner P389-409 Am. Min. 1947
July & August

assume reader knows how to find X, Y, and Z & meas. 2V.

1. roughly sketch grain
   - label subindividuals
   - locate X, Y, & Z. and bring relate to plane of microsection
   - make at least 2 directions coincide with E-W axis

note
clear
enough
to make
notes on..

Universal Stage Nov. 13/62

-45° = 271.7

316.7
+45.0
361.7°

zero mic. stage = 316.7 -90° = 226.7

outer vertical = 90.6 -90° = 0.6

Good. 1. For "setting-up" universal stage P11-22 Emmons
2. For orienting uniaxial crystals P23 & 24
3. " " biaxial " P26 & 27
4. For Corrections for rotation (for variations in R.I. of hemi. & crystal) P41-51 esp. P41, 43, 44, & 50

Summary for Orientation of Biaxial Crystals

P26 Emmons 1. Turn to ext. on I.V.
- biaxial if comes out of ext. on both NS & O.E.W. rotation
2. -*if necessary rotate 90° on I.V. so least departure from ext. on N.S. - ie. steepest of 3 symmetry planes is now ~ EW by steep N or S.
*3. - make this steep symmetry plane V.
- by rotating slightly north or south I.EW.
- return to ext. on I.V.
- check to see if further out of ext. on NS or less out of ext. - then gradually make it not go out of ext. on NS.
- then 1 sym. plane // analyzer (EW) & vert.
- other 2 strike NS - one dips W - one east
- ∴, a NS. rotation make 1 vert.

4. to do this; therefore, have to turn several degrees on O.E.W. opp. incl. of I.EW - out of ext. (now sym pl. inclined ~~to~~ & strike EW)
5. rotate to ext. on N.S. (2 possibilities - take closer)
6. turn O.E.W back to zero.
∴, has 2 vert. symmetry planes - 1 // NS & 1 // EW & 1 ~~vert.~~ hor.

- Then for optic plane
a. - rotate mic-stage 45° - rotate on outer EW - if ext. found
b. rotate on NS (easiest if rotate then O.EW. again) is optic plane.
c. if opt. pl. hor. rotate 90° O.V. 90° on NS.
- when have opt. axis ∠ to 0° O.EW. = V rotate 90° on NS use gyps gives x or z.

Rotation Corrections

1. Index of Ref. - Hemisphere < crystal — minus cor.
   " " > " — plus correction
2. Select mean R.I. of crystal.
3. Use plate 8 - to find ∠ of inner stage after normal rotations on NS & EW axes
4. Use plate 9 & then plate 8 again for rotation on O.E.W.
5. Scale of net is so small - not very accurate - mainly use for steep inclinations & highly variable indi

	Index of Ref.	Nx	Ny	Nz
Winchell	Orthoclase -	1.5190	1.5237	1.5260
P276	Microcline -	1.5224	1.5264	1.5296
	Albite -	1.525	1.529	1.5305

hemisphere used
1.516.

micr. 1.526
alb. 1.528

Procedure for Operating the X-Ray Diffractometer

A Preparation of Sample

1. If coarse enough use clv. plates from broken Xtl. or for finer grained rocks - crush & sieve
   - use 100-150 mesh size
   - use heavy liquids to sep. grains
2. Grind for at least 5-10 minutes by hand.
   - mount on glass slide
   - smear of nail polish
   - brush powder onto smear
   - ~~pr~~ compact " - can use ~~flat~~ side of Razor blade
   - clean off excess powder.

B

Any Order

1. Use Cu Radiation & Ni O filter
2. Set "Limit" switch at oscillation
3. Set gears so that 4 chart lines = 1° 2θ (ie. - big gear to left of small gear)
4. Set "wings" behind geiger for oscillation
   - any range that you want
     - for Or - Ab+An content - a using Quartz internal standard ~20.0 - ~22.5
       b " KBrO3 " ~20.0 - ~22.5 ° 2θ
     - for An - Ab content - osc. ~29.0 - 32.0.
5. Set "Range" switch at X5 or X1 which ever desired
   - In order to distinguish peaks from background, I used X5
6. Set Timer ahead (5-6 hrs. etc.)
7. Chart drive off & clutch disengaged - turned to the right (handle below 2θ adjustment)
8. Make sure Kilovolts & Milliamperes are turned down completely & X-Ray Port is closed
9. Push "Start" switch & listen for water circulation (- near wall)
   - let machine warm up.
10. Push "On" switch

- Rectifier-1 & Rectifier-2 lights will flash on - indicating that the Rectifiers are working
- then X-Ray light will come on

11. Place pen on line & mark 2θ value on line (only approx)
12. Simultaneously engage clutch & turn on chart drive.
13. Open X-Ray Port
14. Good luck.
15. I leave the machine set up the way I found it.

P.S. - made plag. $(1\bar{3}1)$ & (131) run prior to adding $KBrO_3$ - added ground $KBrO_3$ to surface of mount then compacted - works very well.

Heavy Liquid Separation

1. Bromoform - Sp. G. < 2.8 — use alcohol to dilute ∴ lesser Sp. G.
   (Purified - code 1474)
   5 lbs.

2. Acetylene Tetrabromide - Sp. G. - 2.92 — use nitro-benzene to lessen Sp. G.
   -* can't use alcohol.

standardize liquids used - standardized by measuring Sp. G. of various minerals.

1. Scapolite — G = 2.74+ - at 2.75 - Feldspar floats - pyroxene + apatite etc. sink.
   Anorthite (2.76)
   Byt. 2.78

Quartz 2.65 → ∴ goes with plag.

2. Albite - 2.613 Ab just sinks - all plag. sinks
   Albite 2.61
   olig. 2.64

3. 2.59 - K- floats, composite grain sink (perthites may sink
   depends on Na
   - Sanidine - 2.57
   - Adularia - 2.57
   - Anorthoclase - 2.56 - 2.60
   - orthoclase - 2.57
   - Microcline - 2.55

- K-211 - just about solely plag. - sank in liq. ≃ 2.60+
- K-153 - pink k-feld. & green plag. sep. - used liq. ≃ 2.60+.
- K-187 - k-feld. + plag. sep. - used. liq. G ≃ 2.59.

Thin Sections

1. Saw 1 x 1$\frac{1}{2}$ x $\frac{1}{16}$"
2. #240 carb. (coarse) wash
3. #95 Al_2O_3 wash
4. Clean glass slide – heat to 130°C
5 wash rk. slice & place on " (130°C)
6. apply #70C Balsam stick to prepared side of slice
7. allow time for " to penetrate pores
8. Press slice to glass slide
9. Invert & apply wood handle (by Balsam)
10. coarse #240 carb (wash)
11. fine to standard 0.03 mm (wash)
12. Place slide at heat of 100°C
13. apply dab of Pure Canada Balsam
14. Place (pre-heated-100°C) cover glass
15. Cool & remove excess Balsam with razor blade
16. Wash clean with Xylol.
17. Mark & date.

R. V. Kirkham
Feb. 20/61

- This is a review of two papers on yttrium bearing garnets.

The first is a paper By H. S. Yoder & M. L. Keith of the Geophysical Lab. Wash.

entitled <u>Complete Substitution of Aluminum for Silicon: The System $3MnO \cdot Al_2O_3 \cdot 3SiO_2 - 3Y_2O_3 \cdot 5Al_2O_3$</u>

Am. Min. V36, 1951, p.519.

- Thermal, optical, & x-ray data indicate that there is a complete solid solution series between spessartite, $Mn_3Al_2(SiO_4)_3$, and yttrogarnet, $Y_3Al_2(AlO_4)_3$
- The substitution $Y^{+3}Al^{+3} \rightarrow Mn^{+2}Si^{+4}$ may be represented by the formula

$$(Mn_{3-x}Y_x)Al_2(Si_{3-x}Al_x)O_{12}$$

- Yttrogarnet has cube edge of 12.01 ± 0.02 Å & space group O_h^{10}.
- It was pointed out by Jaffe (1950) that some spessartite garnets contain as much as 2.6% Y_2O_3. He suggested the complete subtitution of Y for Mn & that it might be obtained by synthesizing yttrian spessartites. It was for this reason that the authors studied the system experimentally.
- They describe the preparation of the mixtures of various compositions to be used in themal investigation.

<u>Methods of Thermal Investigation</u>

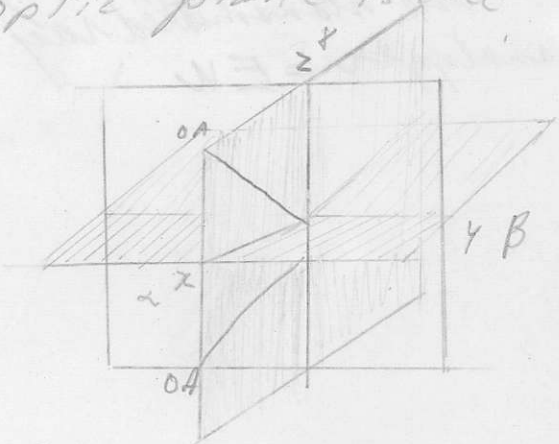
- They then describe their method of themal investigation, emphasizing that it is of an exploratoy nature. The thermal investigation was to determined the phases present at various temperatures. The results are listed in a table.
- ~~From the~~ The results ~~show~~ demonstrated that there is continuous solid solution between spessartite & yttrogarnet
- The liquidus near the end member $3Y_2O_3 \cdot 5Al_2O_3$ is complicated by the existence of two crystalline forms having that composition. There is a high form yttroalumite which forms at 1970°C ± 50° from the low form yttrogarnet.

plane of polarizer - usually NS
- alway polarized light ; only one transmitted ray c

plane of analyzer = EW

3 symmetry planes (all ⊥)

optic plane is one



$\beta = y$ = mean ray

$\gamma = z$ = slow ray = highest n

min. (+) = extraord. ray

↙ ellipsoid surface

— inside sphere

intermediate $\gamma + \alpha$ = ray = β

= optic axis positn

Plan
mic. stage
the two
transmitted rays

.7 % Zn Ag —
.7 % Hg Au —
.01 % Cu
100%

Spec. for Au Ag

Things to do - measure 2V of plag. & refractive Indices det. for composition

Emmons say not reliable on plag. over An_{50} + useless over An_{70}

U. of N Mex.
U. of Idaho
U. [illegible]

confused ext. when walls of twins overlap.

+ not Fedorow for narrow twin lamellae

Use Rittman zone method for comp. of highly zoned xtls.
Turner (Am. Min. 1947) says it is inaccurate

Emmons (1953) some error in 2V by doubling V
- optic axes may be different distances from bisectrix
- error up to 2-3° (P32)

* measuring several grains helps. - statistical average.

* Rittman & Fedorow methods are complementary
Low An, narrow twins or zones. — high An

Rittman zone method

- plag. is oriented crystallographically not optically (as for 2V det.)
- to one of many suitable positions & ext. ∠'s are measured.
- ext. curves for comp.

Easiest - composition plane, // cross-hair & axis of microscope
- ∴ need twinned crystals
- rotation on axis ⊥ comp. pl. - comp. pl. remains vert. & ext. changes.
- several reference positions eg. c, Carlsbad tw. axis

all axes at zero positions
1. rotate comp. pl. NS. on inner vert.
2. make vert. by rotation on NS. (not easy - test on O.E.W.)
3. test optical character of zone axis. - rotate mic. stage 45° till O.E.W. // slow ray of accessory plate
   [⊥(010) always ~~fast~~ slow ray; sec. order colors. ⊥(001) or rhombic sect - fast & slow)
4. return mic. stage to zero. & rotate on O.E.W. to find ref. position (clv., ⊥ comp. pl., max ext. or twin axis)
5. clv. or ⊥ comp. pl. - make vert.
6. measure x'(α') to N.S. comp. pl.

Fig. 58 P127

6th

Perutz

II

Dear Sirs:

I am interested in enrolling in your faculty of Graduate Studies with the intention of obtaining a Ph. D. in the field of Geology. Would you please send me the necessary application forms and a calander. (II.H.) My wife would also like to enter in graduate work in the music. Would you also include the neccessary applic. for her.

pertinent

TABLE I

Table of Formations for the Mitchell-Sulphurets Region

Period	Group	Lithology
Recent		Unconsolidated glacio-fluvial and glacial deposits
	Unconformable Contact	
Tertiary (?)	Late Dykes	Keratophyre (basalt (?))
	Intrusive Contact	
Jurassic (?)	Mitchell Intrusions	Granite Syenite and Quartz-Syenite Porphyry Plagioclase-Hornblende Porphyry (Albite Syenite; minor Syenodiorite) - and altered equivalents
Intrusive Contact		
Lower Jurassic (?)	Lower Hazelton and/or possibly Upper Takla (?)	*Spilitized Diabase
		Intrusive Contact
		Volcanic Members - green and purple lapilli tuff, volcanic breccia, feldspar porphyry - and altered equivalents
		Unconformable or Conformable Contacts (?)
		**Sedimentary Members - carbonaceous argillite, siltstone, greywacke, conglomerate, and minor impure limestone - and altered equivalents

* May be part of the Mitchell Intrusions

** There is some doubt whether the main sedimentary unit in the map area is stratigraphically above or below the main volcanic unit

TABLE III

Typical Mineral Compositions of Volcanic Rocks in the Mitchell-Sulphurets Region

Specimen No.	K-85	K-246	K-291	K-247	K-84
Rock Name	altered volcanic breccia	altered lapilli tuff	altered lapilli tuff	altered tuff	altered feldspar porphyry flow
Plagioclase	15% An_{0-5}	35% An_{0-5}	25% $An0$	25-30% An_{0-5}	35-40% An_{22-25}
Apatite	-	trace	trace	trace	3% (+sphene)
Epidote (pistacite)	-	4-5%	45%	-	5-7%
"Sericite" (±clay minerals)	60%	12-15%	1-2%	12-15%	10-12%
Calcite	-	8-10%	7-10%	17-20%	3%
Chlorite	-	5-7%	5-7%	7%	15%
Biotite	trace	-	-	-	-
Quartz	-	3%	-	5%	-
Unresolvable mesostasis (plagioclase ?)	15-17%	25%	10-12%	20%	10-15%
Opaque Minerals	7-10%	2-3%	1/2-1%	6-8%	6%

An% was determined by optical means.
Most of the minerals are probably secondary.
Percentages are visual estimations.

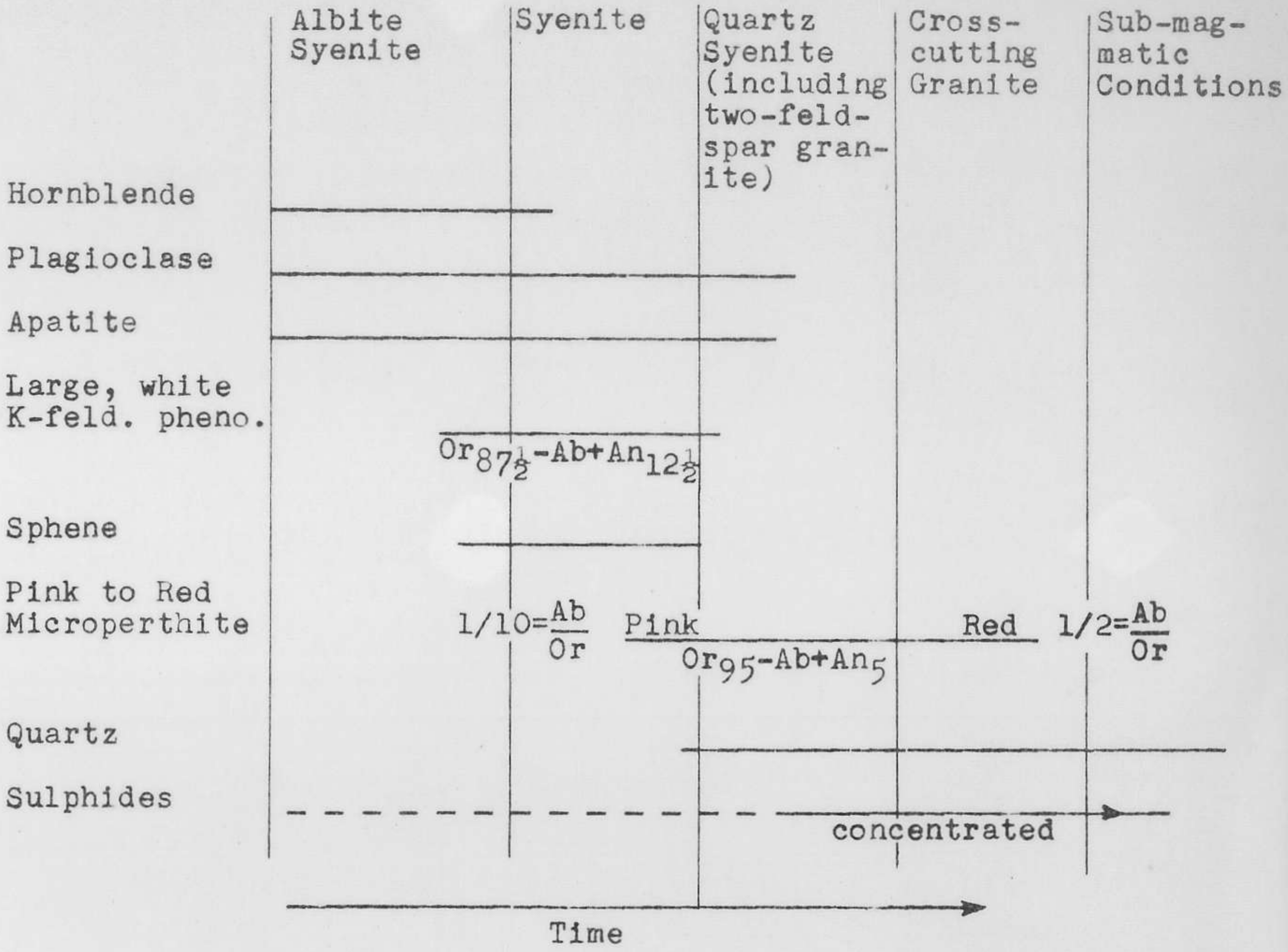


Figure 9: Paragenesis of the minerals in the Mitchell Intrusions.

two, on the other hand, strongly suggests a common origin. The very position of all the intrusions makes it difficult to suppose anything but a close relationship between all the members of the Mitchell Intrusions. Although rather secondary evidence, the fact that disseminated copper, molybdenum, and iron minerals are found associated with all members supports a common origin.

If we first consider the origin of the syenite,