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Candidates requiring additional books or other supplies should rise without leaving their places.

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The plea of accident or forgetfulness shall not be received.

ORDER OF QUESTIONS

List the numbers of the examination questions in the **left column** in the order in which the questions were attempted.

* K-288	Porph.
✓ K-93	"
✓ K-23	"
K-200	Dyke
✓ K-153	Porph.
✓ K-187	"
K-222	Trachyte Porph?
K-270	alt. " "?
K-211	Hybrid } End of M. Ridge
K-209	Diabase }
K-210	Porp }
* K-243	Late Basaltic Dyke. incl. arg. alt. K-124 K-120 K-126
* K-242	Porph.
* K-126	} Highly Alt. Porph. — assoc. with Arg.
* K-124	

K-127 highly chl. & epd. porph.

✓ K-196 - Porph.
* K-132 - Dyke (Trach.?)
✓ K-22 - Porph.
* K-238 - John's Peak
K-120

* K-112 - Trach. Porph
* K-116 - Epi. " "
* K-119 - Large Feld. xtl. "
K-185 - Sh. Porph.
K-191 + K-190 → ore zone Porph.
K-195 + K-197

Things Noted About High Chalcopyrite Rocks

① Lack of Mafic Minerals – Hypothesis – destroyed by volatile attack on falling temp.

② Generally high Microperthite content – ~70%
– some ~40-50% Albite
lower chalco rks. K-153 ~20% Microperthite

K-187 – ~40% Microp. + ~30% Albite – no chalco.

Hypothesis – Microperthite formed at temp. below formation of other feldspar
– Chalcopyrite " " " " Micro. + but closely following
∴ generally high Microper. rks. have some chalco. in vicinity

*– Metasomatic Granites don't have any mafics.

– History & complex & local environments have obviously played an important part in the ~~orige~~ history of the area ∴ require very detail study to achieve complete understanding of history. This is not possible in the scope of this thesis

– Color is diagnostic of history
white – reasonably fresh
qtz plag. – sericitized
red k-feld. – secondary microp.

– High alunite $KAl_3(OH)_6(SO_4)_2$ or natroalunite $NaAl_3(OH)_6(SO_4)_2$ may be related to high gold areas

– Alunite Pg 26 un. (+); length fast (chl. & cryst.); sec. blue; low (+) relief; ∥ or sym ext. .020

– Pyrophyllite Pg 29 – $Al_2(OH)_2Si_4O_{10}$
– low to mod. (+) relief
– .048 – upper 3rd order
– 2V = 53°-60° (–)
– perfect cl. ⊥ length slow, ∥ ext.
– similar to talc & muscovite

– for ~~ist~~ x-ray check – albite
– allophane
– pyrophyllite
– alunite

K-22 Hand-specimen

Minerals & %'s & Texture

- ~1% sulphide ($\frac{3}{4}$ chalco. - $\frac{1}{4}$ pyrite) & minor gray metallic (specularite? magnetite?) - very fine grained usually < .5 mm.
  - disseminated throughout - sometimes along minute fractures
- ~40% feldspar phenocrysts - (white, sometimes thin pink border, untwinned, 2 clv. ~90°, euhedral & subhedral, often cracked & offset along minute fractures; coarse grained - some exceed 20 mm in length - av. ~5 mm by 2 mm.
- ~2% dark blk. clots - up to 2 mm in dia, Hard. > 5½
- ~45% aphanitic to fine grained qtz-feldspathic matrix - grey or pinkish - where pinkish? - coarser grained

Megascopic Name - (K-feld.) Porphyry.

T. S.

Minerals & Properties

Feldspar. - (Mainly Microperthite - minor plag)

~70% Microperthite - $\frac{\text{K-feld.}}{\text{plag.}} = \frac{4}{1}$; colorless; dusty - alt. to clay minerals; 2V > 60° 2V ≈ 90° ✓ definitely zoned untwinned; distinct (-) relief; low bir.; n < gl. ? diff. to distinguish from K-feld. — n K-feld. distinctly < plag. ~ balsam but (-) indistinctly (+)

Plag. (albite) - in matrix. - colorless; unaltered; sutured boundaries; very fine grained < .1 mm; seen replacing large dusty Micro. xt/s; poly. twinning.

~20-25% plag.

max. ext. ⊥(010) -

8° - 8° = An_{12} or An_{25}

6° - 7° = 6½° = An_{14} or An_{24}

17 & 17° = An_0 or An_{31}

1/2-1% opaque minerals → alters to chlorite & assoc. with opaques ? Epid. – high relief & mod. bir. 2 mag. 55 → strongly pleo. green; ~ iso or low bir. dark N.S. + relief; small irregular vesicles ? ich.

5% Carbonate – colorless; extreme bir.; multiple twinning; unevenness (–) figure with many cleavage lines

1-2% Trace Unknown (epid.? or muscovite probably) or talc etc; high bir. – 2nd colors; high (+) relief; colorless; 1 per clv.; ∥ ext.; length slow biax (–) small 2V ≈ 15°

no clv.; very clear colorless

Trace – isotropic; extremely high (+) relief – along fracture with carbonate

Trace Unknown: – high + relief; colorless; low bir.

– may be some qtz in matrix but less than 5% ~~then~~ only fine grains

Trace Tourmaline?

Texture – Porphyritic

little opt of mus. & carb. crystals – may be replace. of fermic minerals

Mosaic – subself matrix

Argument for Replacement
1. Corroded dusty K-feld. phenocrysts
2. Clear, unaltered Albite matrix
3. albite attacks K-feld. from outer borders of – sutured irregular boundaries to K-feld. host.
4. Some of large K-feld. pheno. don't have any albite in core
5. intergrowth are blocky & irregular
6. lack of mafic minerals

Name – altered K-feld Porphy.

History – Magmatic origin – 1st K-feld rk. porphyry or syenitic granite
– Extensive Na alteration – plag. replacement of matrix
extensive shearing fracturing – offset of phen. along fractures partial replace of pheno
– carbonate alteration of muscovite
trace chlorite & chalcopyrite

K-23 H.S. Minerals % & Texture.

~2% chalco. - mostly in ¼" veinlet - but also diss. throughout

~10-15% large (5 mm) white K-feld pheno. - have pink borders.

~10% carbonate

~10% qtz.

~60+% pink. feldspar matrix - mainly fine to med. grained av. 1-2 mm in size

~ equigranular, a few relic feldspar phenocrysts

Mega. Name - Recrystallized K-feld. porphyry

Thin-section - M, Prop. & %'s

10% Plag. - ⊥a $\frac{15\,5}{15\,9}$ · $\frac{19\,1}{17\,5}$ · $\frac{\text{Ⅱ}\,x'}{\text{Ⅱ}\,y'}$ $\frac{\text{i.(-)}\angle}{\text{Clv.}}$ = Ab_{100} — Good Determination

when discrete xt's ↓ mostly small + interstitial n ≈ balsam - very low relief (but in some grains is distinctly (-) below)

~~60~~ 80% Microperthite - $\left(\frac{\text{K-feld.}}{\text{plag}} \approx \frac{1}{3}\right)$.

K-feld. ≈ much plag. distinct (-) relief

- intergrowth is coarser & better developed than in K-22.
- the grains are smaller in size than K-22 & there porphyritic nature is less marked.

~~10~~ 15% Quartz - Uniaxial (+) colorless; low bir; large inter grains

1-2% Carbonate - in very minute veinlets

Trace Muscov. & Chlorite or talc.?

1-2% Opaques

fraction % Apatite - Colorless; mod. to high (+) relief; very low bir. + low 1st grays.; 1 hex. end section isotropic

1 grain sphene - high + relief ◇; high bir.; sl. brownish color. one grain length slow.

Texture - medium to fine grained (1-2 mm av dia)
- the grain size is somewhat variable but there is no marked porphyritic tendency

Name - Granite (but of meta. origin)
History - Same Porph. as K-22 but more extensively changed. - microp. better developed.
- plus presence of qtz.
- The rk. has recrystallized ~~since it~~ 1st porphyritic
- 2nd ~~to~~ approaches equigranular nature & cleaner rk

some plag. + some K-feld.

K-92 H. S.

~15% white feldspar phenocrysts + ~20% more (generally finer) deep purplish red feld. pheno. — all have purplish border & cracks filled

— av. ~2-3 mm in length but up to 15 mm long & 8 mm wide

— remainder is a fine gr. of qtz. to aplitic — feld. matrix

— ~10% of qtz.

Rege. Name — Feldspar (Granite) Porphyry.

History — xtllized as Porphyry.

— then attacked by volatiles?? — recrystallization

— ~~approached~~ tendency to become equigranular.

T. S. M.&%'s & Properties

Feldspar

~75% Microperthite ($\frac{\text{Plag.}}{\text{K-feld.}} = \frac{1}{3}$) — dusty xtls. — as rims on larger other feldspars (plag. & K-feld) and as smaller more equant grains (av. ~1 mm)

~1% Plagioclase — discrete grains also as large xtls — 1 grain ? comp. rimmed by microp. — max. ext. zone ⊥ (010) 16 & 15 — $15\frac{1}{2}°$ = ~ $[Ab_5]$ or Ab_{33} probably Ab_{10}

Composition zoning just inside micro. border. ~1-2% K-feld. — discrete xtls (pheno.) large 2V ~80° on small xtl. Dimmed with microp.

~2% Sericite — alteration product of feldspar.

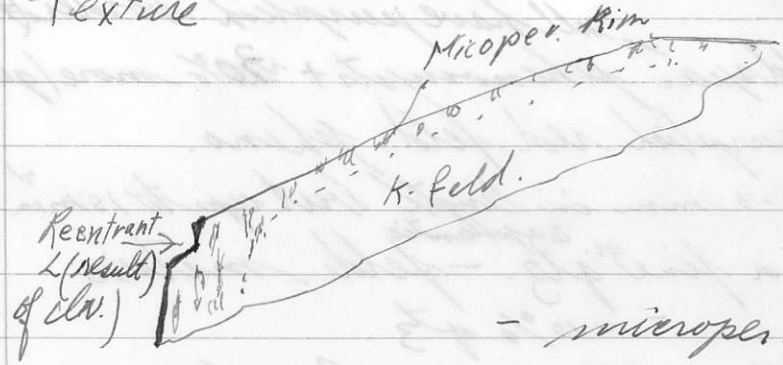
1% Chlorite. — strongly pleo. green — assoc. opaques.

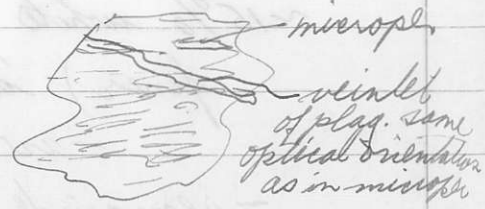
1% Apatite — hex., colorless mod. relief; low bir

2% opaques. very fine — interstitial

~15% Quartz. — anhedral, colorless etc uniaxial (+) — microcrystalline matrix to feldspar.

Texture


Microper. Rim
K. feld.
Reentrant ∠ (result of clv.)


microper.
veinlet of plag. same optical orientation as in microper.

- microper. - is irregular but well developed. - results of replacement or exsolution, bordr growth?

lack of mafics

mosaic matrix of Qtz, K-feld, plag. & microper. & opaques

- fine gr. Porphyritic feld. set in microcrystallic matrix of mainly Qtz.

Name. - Result of metasomatism, ∴, difficult to name
Porph. Microper. - Granite?

History - crystallization of large feld. xtls.
② - broken (fractured & cleaved)??
③ - growth of microper. - rims exsolution or rapid
④ - xtllization of micro. qtz. matrix
- Argillic Alt. - Hydrothermal
⑤ - weathering

as other igneous rks. - very complex history

Make Polished Section

K-153 H.S.

pink seems to be K-feld
green " " " plag. ??

~80% a mixture of subequal amounts of pink & pale green feldspar set ~15% matrix of ?? ~~sulphides~~ feld.? ?? mafics

- med. grained av. ~1-2 mm in dia but some grains exceed 1 while with pink rims, 5 mm diameter
- both feldspars are zoned.
- ~½% identifiable, very fine grained chalcopyrite
- ~5% small vugs.

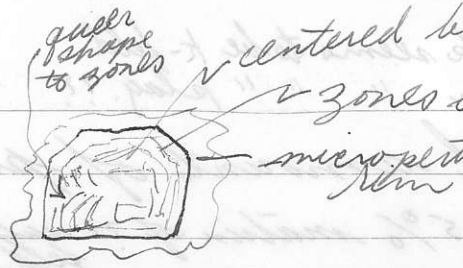
Name - Porphyritic (upper bearing) Syenite

T.S. M., %'s & Properties

more in H.S. coarser grained 10% K-feld. - (Pink in H.S.) zoned; colorless; distinct (-) relief; low bir.

~45% Plag - (Pale Green in H.S.) - high alt. to sericite; polysynthetic twinning
zoned max. ext ⊥(010) 15°/16° small grains ∴ probably Albite Ano
17°/17° natural grain ∴ ?An 4 or An 35 ⊃ (An5 or An34)

15-20% Microperthite - (Plag ~¼ K-feld) rims other K-feld. & in discrete XTLs.; interstitial like glass. & not containing sericite
7-10% Quartz - microcrystalline; interstitial; uniaxial (+); anhedral; irregular
2-4% Sphene - high (+) relief; high bir. distinctly pleo - pale brown.
~5% Sericite - alt. feld. - mainly plag.
3-5% Chlorite - strongly pleo green; low bir; anomalous brown.
2-3% Opaques -
trace Apatite -
Calcite - colorless; high bir.
? Epidote - anomalous blues - mod bir.



(av. 1mm) – Plag. + K-feld. phenos (1 > 5mm)
set in matrix (av. dia ≈ .2-.3mm)
of mainly microperth., qtz, + plag.

Name – Queer Porphyritic Granite – Syenite ~~Porphyry~~.

History – Crystallization from magma
– 1st sphene.
– 2 feldspars K + plag.
– rapidly changing conditions
– complex zoning
– continued xtllization of interstitial matrix
microp. (also as rims), sodic feld, + qtz.

* ∴, microperthite just late stage of xtllization
– Probably reason why ore minerals are assoc. with it.
– Rk. originally xtllized as 2 feldspar rock in Volcanic environment.

Late Argillic Alt. (of Plag.)

often pink but white core.

zoned

~20% phenocrysts up to 15 mm in long & 4 mm wide X'ls

K-187 H.S. Minerals - %'s - & Texture

~60% K-feld - pink & white some large porphyritic X'ls

~20% Plag. ? interstitial pale grn. & white

~5% Quartz " " fine grained

~3% ? Sphene - euhedral, transparent brown, some large crystals 1 X'l = 5 mm in length

~2% Magnetite - very fine grained - magnetic,

~10-15% Hornblende - black, 2 clv. ≈ 60°

~2+% ? Epidote - alteration of Hb. - fine pale grn. needle.

~3% vugs.

- subequigranular - mainly subhedral - but variable

- medium grained av. ~2-3 mm.

Meg. Name - Slightly Porphyritic Syenite - Approaches Granite but only ~5% Q + Z.

T.S. Minerals, %'s, & Properties

① by difference in extinction

② by bands of microper.

③ outlined by alteration

④ not relief difference

same in all slides

~10% ? K-feld. - distinct (-) relief; untwinned; zoned; 2 clv. ≈ 80°; mainly cores of micro. X'ls

~40% ? Microperthite - borders on K-feld. & interstitial - (Plag / K-feld ≈ 1/3)

~30% ? Plag. - generally interstitial - a smaller than K-feld. phenocrysts. albite

- albite twinning; n ≈ balsam - no distinguishable difference

other grains - low but distinctly (-) relief;

~7% irregularly distributed Quartz. - Uniaxial (+); colorless; low bir. etc.; interstitial - irregular boundaries - ~equant grains - generally ≤ 1/2 mm in dia.

crystals have grown into interstices - Plag. Feld. Qtz ; low (+) relief

~5% Hb. - Corroded crystals; skeletons - sub-euhedral to euhedral; moderately pleo. ext. generally ≈ 15°

medium green; 2 good clv. ≈ 60°; mod. to low bir. - max upper 1st orange.

~1% Epidote - high (+) relief; mod. bir. - 1st oranges; anomalous blues.; 1 clv. - inclined ext. highly

fraction % Apatite - Colorless; low bir. mod. (+) relief

~1% Sphene - biaxial; high bir. - strongly pleo. ≈ pale brown - fractured crystals - outlines euhedral

1% Sericite - Alteration Prod. of feld. - mainly of Plag.

~2% Opaque Minerals -

fraction of Carbonate - assoc. epid. - highly var. relief - both (+) & (-)
high bir. - colorless.

1% Chlorite - Pleo. grn; anomalous browns; radiating xtls; 1 perf. cl.; // ext.; low bir. - 1st grays; alteration of Hb.

Texture - much of microperthitic borders is very late - it is seen including the very fine grained matrix
- complete gradation in grain size from over 8 mm in length to < .1 mm. av. ≈ 1 mm
- mainly subhedral but many grains have irregular borders.

Microscopic Name - Syenite - Granite (on boundary) Slightly Porphyritic

History - 1st - xtllization of K-feld. high temp. - to explain zoning
- either accompanied by, followed or preceded by Plag. (albite) smaller xtls
- + Hb
- + sphene + apatite?
∴ expect to later

2nd - xtllization of matrix
K-feld, Albite, Microperthite, Qtz.
↓ developed in solid state on falling temp.

3rd productions of 1. Epid. & Carbonate - saussurite
2. sericite
Argillic Alt. Hb. 3. Chlorite
4. Magnetite
on falling temp as secondary products from feld. + Hb.

May Warrant Polished Section

K-196 H.S. M., %'s, & Texture

~ 15-20% K-feld. - pink & white zoned xtls - usually large - av ~~4~~ 4 mm in length

~ 60+% Plag? - very pale green - usually smaller than K-feld.

~ 15% very fine grained to aphanitic matrix (feld. chl.

~ 1% chalcopyrite diss. throughout

~ 5%? qtz. - interstitial, fine grained

~ 10% mafics - " " - mainly chlorite?

- 1/4" veinlet of qtz. & very coarse chlorite on one end of specimen - veinlet contains chalco

- mainly subhedral - medium grained av. 1-2 mm

Mega. Name - Syenite to Granite

T.S. M., %'s, & Properties.

~ 25% K-feld - zoned xtls. - centered ~ centered optic axis - depending on zone. - near border 2V ≈ 30°-70° (-) good; in center ≈ 50°-70° (-) very difficult to be certain because slightly off-centered

- one central zone 2V > 60° centered bir. good. Probably orthoclase

zones are marked by microper. layers & variations in ext.

mainly microperthite in matrix microcrystalline with qtz

~ 30% Plag - highly altered,

albite - ~ sl. > K-feld but much < qtz.

~ 20% Microperthite - some K-feld. is probably cryptic-perthite - very fine intergrowths - not well developed. ~ Plag / K-feld = 1/6

7-9% Chlorite - very low bir.; strongly pleo. gray.; 1 per clv.; anomalous brns. interstitial

1-2% Apatite - ⬡ isotropic hexa. end-section; uniaxial (-);

3% Sericite - alt. of Plag. & some coarse flakes assoc. with chlorite

2-3% Opaques - finely diss. - assoc. with chlorite

1% Carbonate -

10-15% Quartz - Uniaxial; in matrix or in cross-cutting veinlets; small irregular grains

Trace Epidote -

Texture: - Porphyritic

~40% Matrix - microcrystalline K-feld. + Qtz.

~50% ~~Crystals~~ Phenocrysts - ~30% Plag. - 20% K-feld (including microp. + microperthite mainly)

- ~~Plag~~ Plag. phenos. av 1-2 mm in size
Microper. + K-feld phenos. av. 2-3 mm in size

Phenocrysts - although corroded mainly are ~~[illegible]~~ subhedral.

Matrix - anhedral K-feld + qtz.

- Micro. Name - Altered Granite Porphyry
Approaches Syenite

History - 1. Crystallization from magma of high temp. - K-feld. (zoned sanidine?, Plag (zone high temp. albite?) + Hb. ? (destroyed) + Apatite

2. On falling temp. development of Microperthite - short stage - microper. beady exsolved. continued K-feld matrix + qtz.

3. Hydrothermal activity a. Hb. completely destroyed transformed to chlorite (minor epidote + calcite)

b. Plag. - highly sericitized (argillic alteration) [Argillic Alt]

c. Still crystallization of qtz.
- a sec. qtz. period - the cross-cutting veinlets
- here there may have been an addition of silica to matrix.

d. emplacement of chalcopyrite

some fracturing → probably time for zones of brecciation in porphyry

? slight amount of silification

International Geological Congress
Report of the Twenty-First Session
~~Det~~ Norden
1960

Det Berlingske Boktrykkeri
Copenhagen 1960

concerned, then the Department of Mines would pay me part time for writing up the work as a thesis. Besides the above, from these sources, I would also appreciate any assistance that the university might be able to offer.

Yours truly,
R.C.H.

My wife has full ~~teaching~~ qualification for teaching in a secondary school. If it is possible to obtain employment she may be able to finance part of my education