IMPORTANT MESSAGE

FOR Louise

DATE 9-7 TIME 11:20 (A.M.) P.M.

WHILE YOU WERE OUT

M Dan Carrier

OF Unocal

PHONE NO. (707) 545-7600 ext. 131

TELEPHONED	✓	PLEASE CALL	✓
CALLED TO SEE YOU		WILL CALL AGAIN	
WANTS TO SEE YOU		RUSH	
RETURNED YOUR CALL			

MESSAGE Call before noon (on time) or else tomorrow morning.

SIGNED CD

not Tues. / 17 group - GRC - 10th Oct.

PRINTED IN U.S.A.

JBH

★ Random notes for final rept. for ~~[illegible]~~

[similar but sl. more coarsely xlln microdiabase]

★ Rock types —

all but 8-10 & 8-18 are porphyritic to aphyric (dominated by) basalt to basaltic andesite. All or most appear to have been contained primary pyroxene, mostly now altered to a variety of secondary phases; a few chips conceivably may contain trace to minor amts of primary hornblende, but I doubt it (probably actinolite after all and after a good, hard look).

✱ 8-10 is qtz latite to qtz micromonzonite essentially identical to that documented for ~~[illegible]~~ previously analyzed smpls. 6-1 & 6-2. well-developed spherulitic & granophyric, & micropegmatitic textures locally present. could be a thick flow dome or shallow ~~intru~~ (hypabyssal or subvolcanic) intrusive.

✱ ~~8-18~~ is a rhyodacite to microgranodiorite with a sub-trachytic texture — looks more a flow rock than 8-10 but difficult to say for certain — conceivably also could be dome or shallow intrusive

8-17 breccia

c:\wp50\8-series

Alteration

Like the "6" series rx, 8-9 to 8-17

Most ~~widespread actinolite and epidote~~, several secondary phases indicative of formation at relatively high temperatures. Actinolite, for example, generally believed to form above 280°C; biotite above 220°C (more commonly above 300°C); epidote above 240°C; other secondary phases in these samples (eg chlorite) are ambiguous as geothermometers. Some of the actinolite conceivably could be detritic in origin, as could chlorite and epidote, but ~~textures~~ The common occurrence of these minerals as well-developed veinlets strongly argues in favor of a fairly high-temperature hydrothermal origin. Discrete smectites in these samples are probably saponites, which as trioctahedral smectites are stable at higher temperatures than their dioctahedral counterparts.

UNOCAL GEOTHERMAL - DANIEL CARRIER

10 CUTTINGS SAMPLES

8-9 TO 8-18

PRELIM. BULK XRD

SUMMARY OF X-RAY DIFFRACTION ANALYSIS

UNIVERSITY OF UTAH RESEARCH INSTITUTE, EARTH SCIENCE LABORATORY

MINERALOGY, APPROX. WT.% [X] (or) RELATIVE ABUNDANCE [ ]

SAMPLE NO.	QUARTZ	PLAGIOCLASE	K-FELDSPAR	CALCITE	ULVÖSPINEL	ACTINOLITE	HORNBLENDE	EPIDOTE	PREHNITE	ANHYDRITE	TOTAL OPAQUES	ILMENITE & TOR MAGNETITE	HEMATITE	PYRITE	SPHENE? LEUCOXENE	WAIRAKITE	SMECTITE	MIXED-LAYER ILLITE-SMECTITE	ILLITE AND PHENGITE	BIOTITE	CHLORITE	OTHER	
8-9	7	45	5	TR	3	7	3	4			20	13	2	5			1				5		TRACE - SERPENTINITE
8-10	43	34	17					1			1						1		2		1		
8-11	9	36	3	1	15	5		5	TR		17						1		1		7		TRACE - SERPENTINITE
8-12	6	40	8	1	6	5.	3.	6	TR		16	6			10		1				8		
8-13	2	39	7		3	12	.	7			21	8			13	.	1				8		
8-14	2	43	3		2	9	1	2			27	14		5	7	?	1				10		
8-15	1	47	6	1	3	10	2	3			20	10		4	6		1				6		
8-16	7	37	12		3	14		11			14						X				11		
8-17	2	35		2	10		13	9				5		2	5				11		4		(NO THIN SECTION)
8-18	18	56	14					8			1										3		
8-9	7	47	5	TR	3	9#	—	4				9	2		9		1	TR			5		TR. SERPENTINE
-10	41	34	17		TR	TR		2				1	TR	—	3		1				1		
-11	8	38	5	1	15	5		5				7	2	—	6		1	1	TR		5		Tr. serpentine
-12	4	46	7	TR	2	8#	—	6	TR			9	TR	TR	7		1		TR		8		
-13	1	49	3		2	10	—	5		TR		10		TR	7		1		1		7		
-14	3	51	3		2	9#	—	3				13		TR	7		1		TR		8		
-15	2	54	3	TR	2	10#		3				10		TR	6		1	—	TR		9		
-16	11	46	—	—	—	7	—	9	—	—	—	7	TR	—	11	—	—	—	—	—	9		
-17 B	1	41	3	TR	—	19	—	5	—	—	—	10	—	1	7	—	TR	—	—	(11)	6		Tr. bornite?
-18	18	45	18	—	—	—	—	7	—	—	—	—	—	TR	5	—	—	—	—	—	7	—	

MM = PREDOMINANT M = MAJOR m = MINOR Tr = TRACE ? = TENTATIVE IDENTIFICATION

10-13-88
S. Lutz

poss. incl. v. minor primary hbl.

REVISED CLAY

UNOCAL GEOTHERMAL - DANIEL CARRIER

8-9 TO 8-18

PRELIM. CLAY XRD

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10-13-88
S. Lutz

MINERALOGY, APPROX. WT.% [X] (or) RELATIVE ABUNDANCE [ ]

SAMPLE NO.	SMECTITE	ILLITE & PHENG. UNAVOIDED	CHLORITE	MIXED LAYER CHLORITE/MICA	BIOTITE	TALC
8-9	16		79	5		
8-10	10	76	14			
8-11	7	15	76	14		8
8-12	4		86	X		10
8-13	8		92	X		X
8-14	15		85			
8-15	18		79			
8-16			100			
8-17B	3*		63		34	
8-18			100			

\+ MAY INCLUDE OTHER 10Å MICA - BIOTITE (NO THIN-SECTION)

? UNIDENTIFIED 9.4Å PEAK

MM = PREDOMINANT M = MAJOR m = MINOR Tr = TRACE ? = TENTATIVE IDENTIFICATION

REVISED ROCK TYPES

	RHYODACITE TO MICROGRANODIORITE	microgranodior.	qtz. latite to qtz. micromonzonite	diabase	microdiabase	basalt / basaltic andesite			[illegible] breccia	gouge / microbreccia					
8-9					m	MM				M					
8-10			MM			TR				TR					
8-11					m	MM				M					
8-12			TR		m	MM				M					
8-13			m		m	MM				m					
8-14				m	MM	M				m					
8-15					MM	M				Tr					
8-16					MM										
8-17					MM				MM						
8-18	MM														

Handwritten notes written lengthwise in the two breccia columns:

clasts - altered as well as matrix — rounded, jigsaw — hydrothermal →

clasts - not altered texture truncated at grains — tectonic →

Note in the box at the foot of the columns: fine ated (fragments - vs stretched matrix no crystals)

UNOCAL GEOTHERMAL - DANIEL CARRIER

VEINLETS & VEINLET FRAGMENTS

10 CUTTINGS SAMPLES
8-9 TO 8-18

PRELIM. VEINLETS
SAMPLE NO.

MINERALOGY, APPROX. WT.% ☐ (or) RELATIVE ABUNDANCE ☐

SAMPLE NO.	QTZ	CHL	KF ± QTZ	EP ± Q, KF	ACT ± Q, KF, EP	CHL ± QTZ	PHENGITE ± IL, CHL, QTZ	PREHNITE ± EP, QTZ, KF	WAIRAKITE ± EP, QTZ, KF	LEUCOXENE	BIOTITE ± QTZ	SERICITE ± QTZ	Talc- act	OTHER, NOTES.
8-9	°TR	TR	✓	✓	✓	✓	TR		MM			✓		KF, EP-PHENG, EP-WAIRAKITE
8-10	✓		*✓	✓		✓								EP-CHL
8-11	✓	✓		✓	✓	✓		TR				✓		EP-PREHNITE
8-12	✓	TR	✓	✓	✓	✓	TR	TR		TR			✓	QTZ-ACT, EP-LEUCOXENE ✓yes
8-13	✓	TR	✓	✓	✓	✓	TR		TR	✓				KF, EP-LEUCOXENE, WAIR-CHL
8-14	✓			✓	✓	✓	TR			TR				QTZ-ACT, KF-CHL, PHENGITE-CHALCEDONY ←?
8-15	✓	TR		✓	✓	✓								EP-KF-ACT
8-16	✓			✓	✓	✓				✓				CHL-QTZ (NODULES), EP-CHL-ACT
8-17	✓			✓	✓*	✓								No thin-section, EP, QTZ (NODULE), EP, QTZ (VEIN)
8-18			*✓	✓										

* MICROPEGMATITIC Q-KESP INTERGROWTH

° CHALCEDONY

TR = SCATTERED TRACES

* W/sphene

MM = PREDOMINANT M = MAJOR m = MINOR Tr = TRACE ? = TENTATIVE IDENTIFICATION

SUMMARY OF X-RAY DIFFRACTION ANALYSIS

UNIVERSITY OF UTAH RESEARCH INSTITUTE, EARTH SCIENCE LABORATORY

* all pale

10-13-88
S. Utz

MINERALOGY, APPROX. WT.% ☐ (or) RELATIVE ABUNDANCE ☐

Veinlets/ veinlet frags

SAMPLE NO.	QTZ	CALCITE	CHL ± QTZ	CHL - EPI	ACT ± QTZ ± KF ± EP	EPI ± QTZ ± K-SPAR	ANHYDRITE	K-SPAR - EPI	EPI - LEUCOX	KF ± QTZ	EPI	EPI - CHL	SERP - QTZ	EPI - ANHYDRITE	SERP - CHL	PREHNITE						
J ✓ 8-9			m		M	m				TR	TR	m		TR	TR							Cpx → act, plag → calc, sericite
S ✓ 8-10			TR			M					MM											K-spar veinlets
J ✓ 8-11	m	m	m		M	MM	TR						m	TR	TR							
S ✓ 8-12	m	m	m	M	m	m		M							TR	TR	TR					some KF flooding
J ✓ 8-13	m		m		M	M	TR	M														K-spar flooding + veinlets
S 8-14	m			m	m					M		M										
8-15	m	TR	m		m								m									
S 8-16			m	M	m							M										chl-qtz devitr. aggregate
8-17 * NOTS.																						
S 8-18						MM						m										

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SUMMARY OF X-RAY DIFFRACTION ANALYSIS

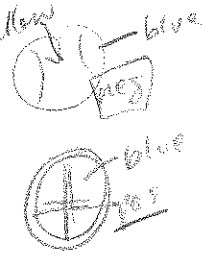
UNIVERSITY OF UTAH RESEARCH INSTITUTE , EARTH SCIENCE LABORATORY

	SAMPLE NO. (veinlets / veinlet frags)	QTZ	CALCITE	CHL ± QTZ	CHL-EPI	ACT ± Q, KF, EP	EPI ± Q KSPAR	ANHYDRITE	KSPAR-EPI		EPI-LEUCOX.	KF ± QTZ	EPI	EPI-CAL	SERP-QTZ	EPI-PREHNITE	SERP-CHL	PREHNITE	
J ✓	8-9			m		M	m				TR	TR	m		TR	TR			cpx → act, plag → cal, seric
S ✓	8-10			TR			M					MM							kspar veins –
J ✓	8-11	m	m	m		M	MM	TR						m	TR	TR			
S ✓	8-12	m	m	m	M	m	m		M							TR	TR	TR	some KF flooding
J ✓	8-13	m		m		M	M	TR	M										kspar flooding + veining
S	8-14	m			m	m					M		M						
	8-15	m	TR	m		m								m					
veins S	8-16			m	M	m							M						chl-qtz devitr. aggregate
	8-17 * NOT C.S.																		
S	8-18						MM						m						

MM = PREDOMINANT M = MAJOR m = MINOR Tr = TRACE ? = TENTATIVE IDENTIFICATION

SUMMARY OF X-RAY DIFFRACTION ANALYSIS

UNIVERSITY OF UTAH RESEARCH INSTITUTE, EARTH SCIENCE LABORATORY



3m quartz

8.16 a piece of rock

groundmass

plag. microlites – ~~microcrystalline~~ ?

minor hb.

some spongy cpx

when is it ?

veinlets –

chlorite

epidote

actinolite ± epidote

yep. chlorite - epidote - actinolite vein

a lot of actinolite –

pleochroic yellow-brown to green

much cleavage in one direction - fibrous

epidote

rare - rich

yellow-green in plane lt

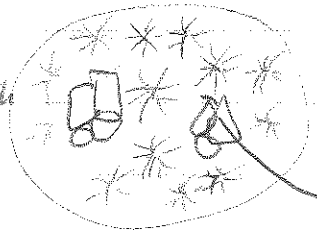
spherule → devitrification

one large chlorite nodules with some epidote.

probably

ch-sm)

greenish-brownish



gfe

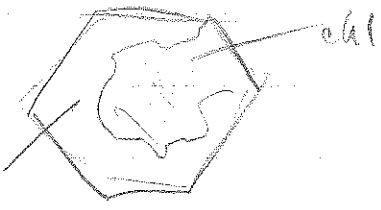
no KF,

50

200 - 270°C

Chlorite - epidote replacement :

olivine



• one fragment — calcite, chlorite, epidote } vein

8-15 breccia
more clay than 8-16

Lots of opaques — $\frac{1}{3}$ po, $\frac{2}{3}$ magn-il?
no veins
lots of hb

no 8-17? 8-18 a piece of rock — not in veins
quite a bit of qtz and kspar
quite a bit of chlorite
not many opaques — 2%

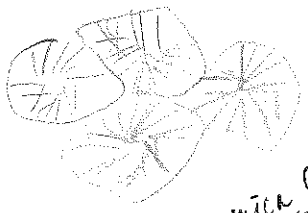
big huge vein:
epidote and very little quartz
and epidote nodules.

using new intensity ratio of $\frac{I_{CH_{100}}}{I_{qtz_{100}}} = .11$

increases % chlorite for 8-group unaltered samples by 4.64 x (present %).

Celadonite - a pleochroic mica - greenish blue - brown

serpentinite →
- also with chlorite - brownish in plane lt



celadonite - a green mica (illite) in basaltic rocks

8-9 basalt or andesite
some porphyritic basalt/andesite
epidote replacing plag
plag - sericitized along cleavage

no phenocrysts - relict
some cpx - relict

qtz micrographic - looks like big qtz vein but rounded edges

vein of leucoxene - and sometimes ghosts??

hematite in with plag microlites
most opaques are prob. magnetite - ilmenite
could be 20% leucoxene - but I don't know

yes one vein: act - qtz - epi - kfeldspar - chlorite

actinolite replaces cpx and hb.

veins - epidote - qtz, calcite (minor), serp - chlorite, celadonite - chlorite, kspar - actinolite, kspar - qtz, stained, actinolite epidote

~~quartz latite~~

8-10 intrusive, intergrown larger crystals with raggedy edges } veins
alot are kspar

plags altering to epidote in center

granophyric texture - (center of thick ash - flow unit?)
↳ devitrification of glass creates intergrowths of quartz and kspar in spherules
↳ spherulitic texture

no veins

veins
large qtz - and euhedral epidote
kf - qtz veins -

hardly any opaques
I don't see illite - mica - phengite.
(maybe leucite in with kf - qtz)

similar to 8-7 = opaques ~ 20% ie

according to Jeffs 90's, then this is actually primary cpx

8-11

Epidote w/ plag microlites → flow-banding

replacing groundmass

Chlorite replacement of glass (at edge of microlite rich fragments

actinolite with minor epidote - only in a few frags.

~~little/no cpx~~ - actinolite replaces cpx?

compared w/ KRP1

more opaques, lots more chlorite, little to no cpx

much more epidote

more clay

cpx - relict phenocrysts -

not many veins -

chlorite veins.

one frag. calcite in vein with chlorite.

one frag anhydrite vein

epidote vein is fractured then infilled with prehnite vein.

colorless epidote with gray-blue birefringence (clinozoisite)

brown CHL-SM

qtz-k-spar-epi-

→ sim to 8-12, only more chlorite

kspar ~~talc~~ - chlorite veins

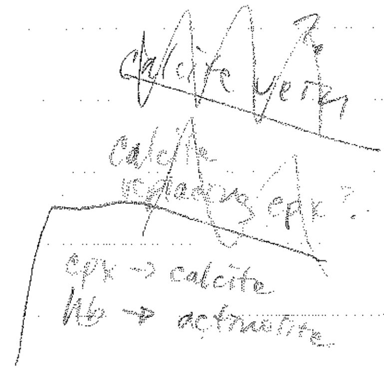
kspar ~~talc~~ chlorite - epidote vein. ~~[illegible]~~ act ~~is~~ chlorite

8-12

relict cpx - grungy

yes, some talc in with chlorite

spherulitic texture in a few frags. most are microlitic clasts.

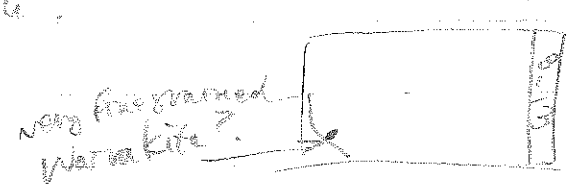


8-13 15% opaques, more clay, less chlorite

some chlorite replacement of biotite

veins... cpx phenocryst - fresh?

kspar-epidote



calcite vein

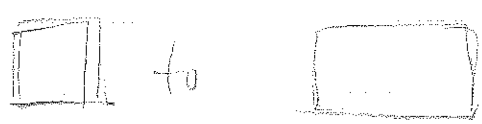
8-14 clay and chloritized feldspars

chlorite -actinolite

not many. qtz veins - & with actinolite ~~needles~~? yes

& qtz veins.

In amygdule fillings →



zeolite

, wairakite? with KF

low birefringence - high relief

actinolite is deuterically replacing cpx?

veins:

epidote - chlorite

M: kspar - epidote

qtz - actinolite

epidote - leucoxene

M

ALL KSPAR IS HYDROTHERM

chengite

8-15 mostly hornblende (not actinolite)
smaller do appear to be actinolite

one k-spar-epidote vein
Chlorite vein
calcite ~~vein~~/epidote vein.
not much epidote.
~~Chlorite~~ amygdule fillings.

calcite vein
fibrous chengsite
in amygdule fillings
with hematite

epidote amygdule

porphyritic granitoid

- qtz monzonite
  subequal kf and plag, anhedral qtz
  [typically perthitic kf (closer to granite comp.)]
  mafic minerals clustered or flow-banded.

qtz latite = rhyolite
an aphanitic monzonite.

andesite
an aphanitic diorite
no qtz, no kf, ± hb or augite
if has biotite → more likely a diorite (granitic)

Dear Dr. Carrier,

Attached are the preliminary results of XRD analysis and reconnaissance petrographic examination of 10 drill cuttings samples which you submitted in early August 1988.

These samples from the 8-group are predominately andesites or porphyritic andesites with the exception of samples 8-10 and 8-18 which contain principally quartz latite or rhyodacite. Sample 8-18 consists almost entirely of qtz, plag and potassium feldspar (in decreasing order of abundance), Sample 8-10 contains more qtz (as well as quartz veins) with some phenocrysts exhibiting dissolution phenomena. Granophyric, axiolitic and spherulitic textures are well-developed in sample 8-10 and some chips of quartz latite in sample 8-12.

Principal hydrothermal alteration products in these rocks are potassium feldspar, quartz, actinolite, chlorite (and mixed-layer chlorite-smectite) epidote and leucoxene. Calcite, prehnite and pumpellyite are rare constituents (non-framework minerals). In the more porphyritic andesites, actinolite appears to replace primary clinopyroxene phenocrysts, especially in samples 8-13 and 8-16. (However, actinolite also occurs in a more prismatic form within quartz veins in these same samples 8-13). In sample 8-16, the actinolite occurs in large vein with epidote and chlorite as well as some replacement of clinopyroxene phenocrysts.

8-11 appears unaltered (relatively)

Potassium feldspar veining and flooding is common in sample 8-13. In samples 8-9, 8-11, some of the primary plagioclase is replaced by carbonate and some by sericite. Epidote (± leucoxene) also commonly replaces plagioclase phenocrysts.

The quartz latite samples (8-10 and 18-18) probably contain as much as 5% primary potassium feldspar and quartz as devitrification aggregates ~~of potassium feldspar and quartz~~. Epidote and chlorite appear ~~to be~~ as the principal alteration products in these quartz latites or rhyodacites.

Unfortunately, a thin-section of sample 8-17 was not made so it is not possible to determine from the diffraction patterns whether the amphibole is primary hornblende or secondary actinolite and whether the 10 Å mica is primary biotite or secondary illite ~~and~~ or phengite. Another problem is an unidentified 9.40 Å peak in samples 8-11, 8-12 and 8-13 which may ~~characterize~~ represent a ~~prevalent~~ talc, not recognized in the thin-sections (although traces of serpentinite are evident.)

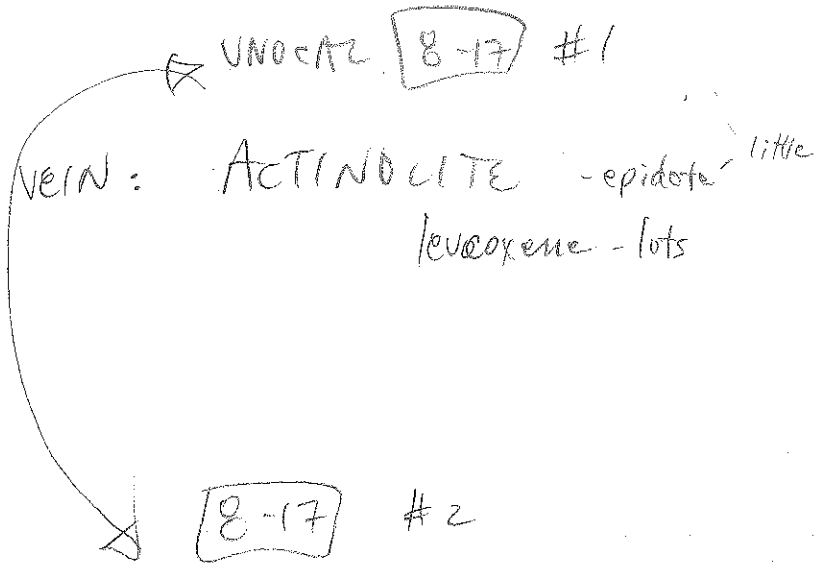
As I mentioned in our phone conversation, a more detailed geologic/alteration report will be prepared after Jeff returns in a few weeks time. I've sent the "17"-group out to be made into thin sections and hope to have a petrominary report on those fairly soon.

Thank you for this great introduction to hydrothermal

mineralogy.
alteration. Please call if you have any questions or if you would prefer only XRD data to be sent initially.

Sincerely.

In general, the alteration assemblages (and vein (and probably the Geothermal history)) and vein of these "8"-series samples are similar to the previously studied "8"-series samples. This group differs somewhat in containing more secondary actinolite and less hydrothermal biotite than the previous "8" series samples.



actinolite - usually ~250°C, more common ~ 300°C
very fine grained acicular crystals in felted aggregates