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ROOSEVELT KGRA, AND ADJOINING AREA, UTAH

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Data update 9/76

Table 1. Localities of analyzed samples of the Mineral Range Volcanics

Sample		
Sample #	Localities	Rock type
MR 74-2	Bailey Ridge flow	Obsidian
MR 74-3	Bailey Ridge flow	Perlite
MR 74-4	Bailey Ridge flow	Pumice
MR 74-7	Big Cedar Cove dome	Rhyolite
MR 74-8	Wild Horse Canyon flow	Obsidian
MR 74-13	Bailey Ridge flow	Obsidian
MR 74-16	Bearskin Mtn. dome	Obsidian
MR 74-18	Pole Line Road	Granite Porphyry
MR 74-19	Pumice Hole Mine	Pumice
MR 74-22	So. Twin Flat Mtn. dome	Obsidian
MR 74-29	Pass Road	Min. Range Granite
MR 75-14	Little Bearskin Mtn. dome	Obsidian
MR 75-18	No. Twin Flat Mtn. dome	Obsidian
MR 75-19	No. Twin Flat Mtn. dome	Rhyolite
MR 75-20	No. Twin Flat Mtn. dome	Obsidian
MR 75-22	Corral Canyon dome	Rhyolite
MR 75-30	Corral Canyon dome	Obsidian

Model analysis of Mineral Mountains igneous rocks (volume percent).

Rock	Quartz	Sanidine	Orthoclase	Plagio- clase	Biotite	Amphibole	Ortho- Pyroxene	Glass	Devitri- fied Glass	Void Space	Ground- mass	Other	Opakes
MR74-2	-	9.0	-	-	0.1	-	-	90.5	0.4	-	-	-	-
MR74-3	-	3.1	-	-	0.2	-	-	94.2	2.4	-	-	-	-
MR74-4	-	4.0	-	0.1	1.0	-	-	84.9	10.1	-	-	-	-
MR74-7	3.1	2.8	-	0.9	0.1	-	-	1.5	91.5	-	-	-	0.1
MR74-8	-	6.0	-	-	0.8	-	-	85.5	6.3	-	-	-	1.5
MR74-13	-	1.9	-	-	0.4	-	-	84.2	13.5	-	-	-	-
MR74-16	-	2.3	-	0.2	-	-	-	97.3	0.3	-	-	-	-
MR74-18	1.0	-	12.7	1.3	0.5	-	-	-	-	0.8	82.5	0.9	0.3
MR74-19	1.5	0.6	-	0.2	0.2	-	-	92.4	0.2	4.7	-	-	0.1
MR74-29	25.9	-	66.4	6.3	0.7	-	-	-	-	-	-	0.1	0.6
MR75-14	2.8	4.7	-	0.6	0.1	-	-	89.5	2.1	-	-	-	0.3
MR75-19	3.9	0.8	-	1.6	1.1	-	-	2.2	86.0	4.3	-	-	0.1
MR75-20	1.7	1.2	-	0.5	-	-	-	96.6	-	0.1	-	-	-
MR75-22	3.8	1.7	-	0.8	0.5	0.1	-	0.3	92.7	-	-	-	0.5
MR75-30	0.4	0.2	-	8.2	1.6	1.4	0.1	86.0	-	1.1	-	0.5	0.5

Microprobe analyses of glass in the Mineral Range volcanics

	74-2	74-3	74-4	74-8	74-13	74-16	74-22	75-14	75-18	75-20	75-30
SiO ₂	76.4	76.8	74.1	77.1	76.5	76.0	75.9	76.5	75.8	76.5	74.8
TiO ₂	0.12	0.12	0.12	0.12	0.13	0.06	0.06	0.07	0.08	0.07	0.14
Al ₂ O ₃	12.4	12.4	12.0	12.4	12.4	13.0	13.3	12.6	12.7	12.8	12.9
FeO	0.73	0.72	0.65	0.74	0.75	0.56	0.48	0.53	0.52	0.58	0.82
MnO	0.06	0.06	0.08	0.06	0.05	0.09	0.09	0.11	0.11	0.11	0.05
MgO	0.09	0.08	0.06	0.09	0.09	0.05	0.02	0.04	0.03	0.04	0.12
CaO	0.55	0.56	0.56	0.55	0.54	0.42	0.41	0.38	0.32	0.40	1.06
Na ₂ O	3.67	3.66	3.29	3.58	3.72	4.14	3.89	4.23	4.23	4.29	3.26
K ₂ O	5.10	5.09	4.78	4.95	4.90	4.26	4.83	4.58	4.57	4.53	5.06
F	0.20	0.14	0.08	0.15	0.13	0.25	0.25	0.34	0.33	0.33	0.03
Sum	99.3	99.6	95.9	99.7	99.2	98.8	99.2	99.4	98.7	99.7	98.2
Less O=F	0.1	0.1	0.03	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Total	99.2	99.5	95.9	99.6	99.1	98.7	99.1	99.3	98.6	99.6	98.2

Mineral Range Trace Elements in PPM

	74-2	74-3	74-4	74-7	74-8	74-13	74-16	74-18	74-19	74-29	75-14	75-19	75-20	75-22	75-30
Ba	125	135	130	85	120	135	-	105	-	10	-	-	-	390	750
Ce	70	60	60	60	65	55	35	30	20	30	45	40	40	60	70
La	45	45	40	40	40	45	30	25	30	30	35	35	35	40	45
Nb	25	25	25	30	25	25	40	30	35	30	45	45	35	25	-
Nd	20	15	20	15	20	20	5	10	5	10	10	10	10	30	35
Pb	contam.	40	35	40	35	35	45	30	35	25	30	30	35	20	20
Pr	10	10	10	5	5	5	5	5	-	5	5	5	5	10	10
Rb	195	195	195	195	200	190	320	250	245	155	340	330	340	160	120
Sr	35	35	40	30	35	40	-	50	5	15	-	-	-	105	270
Th	25	25	20	25	25	25	40	30	35	20	35	35	35	10	15
Y	15	15	15	15	15	20	20	15	15	20	15	15	20	10	15
Zn	40	40	40	45	35	35	40	35	40	20	45	50	45	30	60
Zr	100	100	100	80	100	100	85	80	60	80	85	80	90	85	110
K/Rb	225	220	215	210	215	230	120	170	170	260	115	115	115	275	310

Mineral Mountains Trace Elements in PPM in Volcanic Ashes of Ranch Canyon

	76-7	76-9	76-10	76-13	76-14	76-17L	76-17U	76-18L	76-18U
Ba	-	-	-	-	-	-	-	-	-
Ce	25	25	35	35	35	35	30	40	40
La	30	25	25	25	30	30	30	35	30
Nb	30	30	35	35	50	35	25	40	25
Nd	5	5	5	5	10	5	5	40	40
Pb	30	35	45	35	35	40	30	35	35
Pr	5	-	-	5	5	5	5	5	5
Rb	240	265	290	295	310	295	315	305	295
Sr	10	5	5	-	5	5	-	5	-
Th	30	30	40	40	40	40	35	35	40
Y	15	15	15	15	20	15	15	20	15
Zn	40	45	40	30	45	35	40	40	35
Zr	60	65	70	70	90	75	80	85	80

ppm

Analyses of ilmenite and titanomagnetite

	Ilmenite						Titanomagnetite					
	3	16	19	22	26	30	3	16	19	22	26	30
SiO ₂	0.02	0.08	0.03	0.04	*	0.01	0.03	0.08	0.04	0.28	0.35	0.18
TiO ₂	42.0	46.5	46.7	44.7	40.7	49.8	5.00	4.90	4.73	6.45	5.53	7.51
Al ₂ O ₃	0.13	0.04	*	0.36	0.27	0.03	0.93	0.62	0.63	1.52	1.23	1.86
Cr ₂ O ₃	*	*	*	0.03	0.07	*	0.03	0.03	0.02	0.07	0.06	0.13
V ₂ O ₅	0.23	0.46	0.44	0.49	0.26	0.14	0.43	0.71	0.72	0.79	0.52	0.55
FeO	50.3	44.7	44.8	50.4	53.4	46.6	86.2	85.8	84.7	83.9	84.9	82.6
MnO	3.20	6.40	6.60	2.45	1.73	3.08	0.90	2.61	2.75	1.25	1.37	0.66
MgO	1.50	0.72	0.65	0.32	1.18	0.18	0.80	0.21	0.20	0.32	0.48	0.79
CaO	0.11	0.01	0.02	0.04	*	*	0.09	0.01	0.02	0.04	*	0.02
ZnO	0.17	0.44	0.12	0.30	0.02	0.03	0.26	*	0.29	0.25	*	0.22
Total	97.7	99.1	99.4	99.1	97.6	99.9	94.4	95.0	94.1	94.9	94.4	94.5
Recalculated analyses												
Fe ₂ O ₃	20.8	12.2	11.9	15.0	23.4	5.87	58.6	58.6	58.3	53.6	55.7	51.3
Fe ₂ O ₃	31.6	33.7	34.1	36.9	32.4	41.3	33.5	33.1	32.2	35.7	34.8	36.4
Total	99.8	100.6	100.6	100.6	100.0	100.4	100.3	100.9	99.9	100.3	100.0	99.6
Mol.-%	20.2	12.0	11.7	15.3	18.6		14.3	14.2	13.7	19.4	17.1	22.0
R ₂ O ₃ or Fe ₂ TiO ₄ T(°C)	790	660	650	740	780							
-log fo ₂	12.5	16.8	16.9	14.4	13.1							

*Below limit of detection, 0.01%.

Fe₂O₃ recalculated on ilmenite basis and magnetite recalculated on ulvospinel basis of Carmichael (1967). T and -log fo₂ are taken from curves of Buddington and Lindsley (1964).

Mineral Range Feldspar - BaO & Fe₂O₃

	BaO	Fe ₂ O ₃
74-2		
mph, A	0.15	0.29
74-3		
mph, A	0.20	0.30
74-4		
mph, A	0.17	0.25
74-7		
ph, P	0.02	0.25
ph, A	0.10	0.17
gm, A	0.04	0.26
74-8		
mph, A	0.12	0.32
74-19		
ph, P	0.04	0.23
ph, A	0.00	0.12
gm, P	0.02	0.23
gm, A	0.27	0.15
74-22		
ph, P	0.00	0.30
ph, A	0.00	0.12
75-22		
ph, P	0.04	0.21
ph, A	1.14	0.13
gm, A	0.25	0.13
75-30		
ph, P	0.04	0.39

mph = microphenocryst
gm = groundmass
ph = phenocryst

P = plagioclase
A = alkali feldspar

Mineral Range Feldspar - BaO & Fe₂O₃

	BaO	Fe ₂ O ₃
74-13		
mph, A	0.17	0.29
74-16		
ph, P	0.00	0.17
ph, A	0.00	0.13
gm, P	0.00	0.21
75-14		
mph, A	0.00	0.29
75-18		
ph, P	0.00	0.20
ph, A	0.00	0.18
gm, P	0.00	0.32
gm, A	0.00	0.29
75-19		
gm, A	0.00	0.17
75-20		
ph, A	0.00	0.15
gm, P	0.00	0.30

mph = microphenocryst
gm = groundmass
ph = phenocryst

P = plagioclase
A = alkali feldspar

Mineral Mountain Allanites

	74-16	74-19	75-22
SiO ₂	30.8	30.7	31.4
TiO ₂	1.88	2.04	1.30
Al ₂ O ₃	11.5	11.2	14.3
ZrO ₂	0.02	0.03	0.02
FeO	16.4	16.9	14.9
MnO	1.80	1.83	0.57
MgO	1.17	1.13	1.29
CaO	9.13	9.20	10.5
Na ₂ O	0.07	0.06	0.04
K ₂ O	0.06	0.04	0.04
Ce ₂ O ₃	12.5	12.4	11.7
La ₂ O ₃	9.53	9.41	6.55
Pr ₂ O ₃	1.01	1.05	1.32
Nd ₂ O ₃	1.43	1.52	3.58
Sm ₂ O ₃	0.71	0.71	0.92
Gd ₂ O ₃	0.56	0.37	0.45
Y ₂ O ₃	0.06	0.07	0.12
Nb ₂ O ₅	0.01	*	*
F	0.32	0.32	0.15
Sum	98.6	99.0	99.2
Less F=0	0.13	0.13	0.06
Total	98.5	98.9	99.1

FINAL REPORT

VOLUME 1: Petrology of the
Quaternary volcanics of the Roosevelt
KGRA and adjoining area, Utah

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ABSTRACT

The Roosevelt KGRA (known geothermal resource area) located near Milford, Utah, is associated with a suite of Quaternary silicic volcanics distributed for 15 km along the crest and western flank of the Mineral Mountains, a large Tertiary granite batholith. The volcanics are high-silica rhyolites and occur as domes, flows and tuffs. Initial eruptions resulted in two flows of low viscosity, phenocryst-poor rhyolite. Later activity consisted of pyroclastic eruptions and the emplacement of at least 9 viscous domes. In addition to abundant glass the rhyolites contain alkali feldspar, plagioclase, biotite, iron-titanium oxides and small amounts of hornblende, allanite, apatite, zircon, sphene and topaz. Magmatic temperatures were about 700°C and water fugacities ranged from 350 to 3450 bars. Based on water fugacity calculations we conclude that there may have been one or more shallow magma chambers in the Mineral Range at depths of about 1.6 km.

Introduction

Young silicic volcanics are considered possible indicators of the subsurface presence of shallow magma chambers still sufficiently hot to have potential for geothermal resources. A rationale for this approach is outlined by Smith and Shaw (1975). In the Mineral Mountains, young rhyolite masses extend discontinuously for about 15 km along the range crest; these have been little studied and previously were interpreted as erosional remnants of a single large silicic volcano of Pliocene age (Earl, 1957; Liese, 1957). This report describes the volcanisms of the area, including K-Ar ages which demonstrate that many separate lava dome flows, and tuffs were erupted from vents along the range crest between 0.8 and 0.5 m.y. ago. Along one of the western range-front faults, about 2 km northwest of the nearest rhyolitic volcanic rocks, Roosevelt Hot Springs is located within the Known Geothermal Resource Area (KGRA). The silicic volcanism recorded by the rhyolites of the Mineral Mountains perhaps provides the heat source for the KGRA, (Lipman, et al., 1976 Evans, and Nash, 1975).

General geologic setting

The Mineral Mountains, in west central Utah (Fig. 1), is a typical basin-range horst, which rises about 1 km above the adjacent alluviated basins--the Escalante Desert to the west and an unnamed valley to the east. It extends nearly 50 km in a northerly direction and is mostly about 10 km wide.

On the western and northern sides of the range metamorphic rocks of the Wildhorse Canyon series of Condie (1960), of probable Precambrian age, are the dominant rocks, but Paleozoic and Mesozoic sedimentary rocks

Fig. 1. Generalized geologic map of the central Mineral Mountains, Utah (Lipman, et al., 1976). Tg, granite of Mineral Mountains; Qrl, lava flows of Bailey Ridge and Wildhorse Canyon; Qrp, pyroclastic rocks; Qrd, lava domes; Qac, surficial deposits; Qh, hot springs deposits.

$$-38^{\circ}22'30''$$

are exposed widely on the southern and eastern sides of the range. These layered rocks are intruded by a distinctive body of granite, the Mineral Mountains pluton, which is the largest single outcropping intrusive body in Utah, covering nearly 250 km². This granite and associated pegmatite and aplite may be as young as late Miocene, having yielded two K-Ar ages on feldspars of 15 and 9 m.y. from different samples sites (Park, 1968; Armstrong, 1970). These young apparent ages are supported by preliminary RB-Sr isotopic data, which indicate that the granitic rocks can be no older than mid Tertiary (35 m.y.) and are probably upper Tertiary rocks that have assimilated a significant component of older basement material (C. E. Hedge, oral commun., 1975).

Prior to the onset of late Cenozoic rhyolite volcanism in the Mineral Range, the Mineral Mountains pluton and its country rocks were deeply dissected to form a rugged erosional topography with towering pinnacles rising above narrow mostly dry valleys.

The Mineral Mountains is bounded on the west, and probably on the east side by north-striking normal faults. The trend of the bounding faults on the west is marked locally in the Roosevelt KGRA by discontinuous elongate mounds of opaline sinter and other hot-spring deposits. Near the north end of this trend is Roosevelt Hot Springs. Water temperatures as high as 90°C have been recorded from Roosevelt hot springs, but sometime prior to 1966 the springs dried up (Mundorff, 1970).

Rhyolite of the Mineral Mountains

Rhyolitic rocks in the Mineral Mountains include three stratigraphically distinguishable sequences. Lowermost are two nearly non-porphyrific obsidian-rich lava flows. These are overlain by a pyroclastic sequence, including both ash-fall and ash flow tuffs.

Stratigraphically highest are porphyritic rhyolite lava domes erupted from at least 9 separate vents along the range crest. Cross-sections of domes and flows of the Mineral Mountains are shown in Fig. 2. The domes and flows have a total extrusive volume of $14. \text{ km}^3$. The ash of Ranch Canyon may have contained as much as 0.4 km^3 of material.

Flow of Bailey Ridge and Wildhorse Canyon

The oldest rhyolitic rocks in the Mineral Mountain are two lava flow of virtually nonporphyritic flow-layered rhyolite. One flow is exposed for about 3 km along Bailey Ridge and in Negro Mag Wash northwest of Bearskin Mountain. The other is exposed for about 3.5 km along Wildhorse Canyon, west of Bearskin Mountain. Both flows were originally as much as 40 m thick and followed pre-existing valleys that drained the west side of the Mineral Mountains, with relief much like the present, and that were graded nearly to the present levels at valley fronts. Both flows are only slightly dissected, and much of their primary upper surfaces of frothy pumiceous perlitic rubble are preserved.

Where deeply dissected, both flows display similar cooling and crystallization zonations. The basal few meters of the flow, resting directly on medium to coarse grained granite of the Mineral Mountains pluton, consist of dense black obsidian. The obsidian has well developed flow lamination defined by aligned microlites of feldspars and opaque oxides. The basal obsidian zone grades upward within a meter or two into a well layered zone, in which dark obsidian and light gray or brown finely crystallized flow-layered lava alternate. The interior of the flow is as much as 10-30 m thick, and consists of gray relatively structureless devitrified rhyolite, in places with concentrations of ovoid gas cavities locally filled with vapor-phase crystallization

Fig. 2. Cross sections of flows and domes of Quaternary rhyolite in the central Mineral Mountains, Utah. The feeder pipes shown are diagrammatic only.

NORTHERN DOME

BEARSKIN MOUNTAIN

BAILEY RIDGE FLOW

NORTH TWIN FLAT DOME

WILD HORSE CANYON FLOW AND DOME

NORTH TWIN FLAT DOME

BIG CEDAR COVE AND WILD HORSE CANYON

RANCH CANYON DOME

BEARSKIN RIDGE

SOUTH TWIN FLAT DOME

MINERAL RANGE VOLCANICS

SCALE 1:24000

products. In upper parts of the flow a few meters of flow-layered obsidian are interlayered with divitrified rock passing upward into a more uniform dark glass zone, or grading directly into a frothy rubbly breccia of tan perlitic pumice as much as 10 m thick at the top of the flow.

The flow layering and lamination in these rhyolitic lavas is remarkably planar and uncontorted, in comparison with the swirly internal structures typical of many rhyolitic lava flows. The "ramp structures" that occur commonly in upper parts of silicic flows (Christiansen and Lipman, 1965), are absent or poorly developed, and subhorizontal layering is typical throughout the Bailey Ridge and Wildhorse Canyon flows. The most common deviations from planar layering are small, typically rootless recumbent folds. The limbs of which are usually less than 1 m long. These flowage features, as well as the relatively thin cross-sectional thickness of the lava flows in comparison with their longitudinal extent, indicate that they were characterized by lower emplacement viscosities than many silic lava flows.

Vents for these oldest flows of the Mineral Mountains are obscure. The Wildhorse Canyon flow appears to extend up drainage beneath younger lava domes in the upper part of the canyon, although exposures of the critical relations are poor because of cover by rubble. Probably the vent area for this flow is beneath the younger lavas to the east. If the Bailey Ridge flow vented from beneath its uppermost outcrop area, surface structures of this part of the flow give no indication of any concealed vent. This part of the flow is little dissected, however, and the vent area could be completely buried. Alternatively, the Bailey Ridge flow, and also the Wildhorse Canyon flow, might have come from higher on the slope, underneath the area now covered by the Bearskin

and Little Bearskin Mountain lava domes. However, this would require that the upper portions of the flows be largely removed by erosion while leaving the lower portions not highly dissected.

A single K-Ar radiometric age determination of 0.77 ± 0.08 m.y. from the toe of the Bailey Ridge flow, is the oldest age obtained from any of the Mineral Mountains rhyolites. The Bailey Ridge flow has a reversed paleomagnetic pole position indicating, in conjunction with K-Ar data, that it was erupted toward the end of the Matuyama polarity epoch. The Wildhorse Canyon flow has not yet been dated radiometrically, but it also is characterized by a reversed polarity, which, in conjunction with morphological and chemical resemblance to the Bailey Ridge flow, and its position beneath some of the pyroclastic rocks, suggests a similar age.

Pyroclastic rocks

South of Wildhorse Canyon, pyroclastic rocks of ash-fall and ash-flow origin are the lowest exposed rhyolitic rocks. The main area of pyroclastic rocks is in Ranch Canyon, where tuffs bury rugged paleotopography much like the present land surface.

The pyroclastic rocks are only weakly consolidated and are mostly poorly exposed, underlying alluviated slopes. All the pyroclastic deposits, both ash-fall and ash-flow, are light colored--white to light tan. They occur over an altitude range from 1,950 m in valley-bottom exposures in Ranch Canyon to as high as 2,540 m on the surrounding slopes. Much of the pyroclastic sequence has been removed by erosion in Ranch Canyon, and it is not clear to what extent this altitude range reflects an actual total thickness of the original deposit and to what extent this altitude range reflects an actual total thickness

of the original deposit and to what extent the pyroclastic rocks were thinner but blanketed the preexisting topography. In Ranch Canyon these rocks are overlain by the large lava domes on North and South Twin Flat Mountains and by smaller masses of rhyolitic lava on adjacent ridges. Although contacts between these domes and the pyroclastic rocks are nowhere well exposed, this stratigraphic sequence is indicated by structural zones in the rhyolite domes of North and South Twin Flat Mountains. The lowest exposures are of a subhorizontal zone of basal flow breccia below the basal obsidian zone; this would be an improbable relation if the pyroclastic rocks had been plastered against older lava domes. Thus, the lava dome of South Twin Flat Mountain overlies pyroclastic rocks that are at least 60 m and probably as much as 180 m thick, and these figures suggest minimum thicknesses of the pyroclastic unit.

The lowest pyroclastic rocks are beds of air-fall pumice and ash at least 10 m thick and probably much thicker. Individual beds are a few centimeters to about a meter thick, and bedding dips variably, reflecting an underlying topographic surface on granite of the Mineral Mountains pluton that is as rugged as the present one.

Ash-flow deposits widely overlie the ash-fall beds in Ranch Canyon. The ash-flow deposits locally are at least 50 m thick; probably the total thickness is much greater, but accurate estimates are difficult because of the poor exposures. The ash-flow deposits are everywhere nonwelded and only weakly consolidated; they tend to weather to small conical hills. On especially steep slopes the ash-flow deposits rest directly against granite, with no intervening ash-fall material. In exceptionally good exposures, several flow units--each a few meters thick--can be recognized in the ash-flow deposits, with partings be-

tween the flow units marked by local concentrations of pumice, lithic debris, or better sorted ash.

On the north side of lower Wildhorse Canyon, an isolated patch of pyroclastic material about 150 m across consists of finely laminated white fine-grained ash of lacustrine origin. These beds of water-reworked ash are younger than the Wildhorse Canyon flow and were deposited in a local basin dammed by the flow. The ash has a refractive index similar to that of the pyroclastics in Ranch Canyon, one valley to the south, suggesting that it represents a reworked marginal facies of this deposit. This stratigraphic relation, as well as K-Ar and paleomagnetic data, indicate that the pyroclastic rocks are younger than the Bailey Ridge and Wild Horse Canyon flows.

A single whole-rock K-Ar age on an obsidian clast from ash-flow tuff in Ranch Canyon yielded an age of $0.68 \pm .48$ m.y. providing an older limit for the age of the pyroclastics. The pyroclastic deposits in Ranch Canyon, as well as the local lake beds in Wildhorse Canyon, have normal magnetic polarities in contrast to the reverse polarities of the Bailey Ridge and Wildhorse Canyon flows. Thus, the pyroclastic rocks have been deposited during the Brunhes polarity epoch.

Porphyritic lava domes

The stratigraphically highest part of the upper Cenozoic volcanic assemblage in the Mineral Mountains is a group of at least 9 separate perlite-mantled lava domes and small flows of porphyritic rhyolite. The domes tend to occur along the crest of the range, discontinuously over a zone about 15 km long. These domes form some of the highest topographic points in the Mineral Mountains, including Bearskin Mountain with an elevation of 2772 m (9095 ft.). Individual domes are

as much as 1 km across at their base and stand as much as 250 m high, although dimensions are difficult to determine precisely because of the irregular pre-existing topography and subsequent erosion. Small stubby flows extend out from some of the domes, and some small isolated patches of rhyolite may represent either eroded flow remnants or small separate domes.

The larger domes, such as Bearskin and Little Bearskin Mountains, are little eroded, and surface exposures consist largely of blocks of tan perlitic glass that are little modified remnants of the original brecciated frothy carapace of the dome. Scattered fragments of dense black obsidian, working out through the perlitic breccia, occur about a third of the way above the base of these domes. Float of well layered devitrified rhyolite is exposed locally just above the zone of obsidian fragments. Pumiceous material, that in places ravel out from below the obsidian zone, may represent an initial pyroclastic fall that is nowhere well exposed.

Other domes, such as those of North and South Twin Flat Mountains have been more deeply dissected, in this case by the reexcavation of Ranch Canyon, and their internal structural and crystallization features are better exposed. The internal features of all these late domes are generally similar. A basal black vitrophyric zone is everywhere well developed, in places resting on lighter-colored glassy basal flow breccia. The vitrophyre zone, which is as much as 5-10 m thick, grades into devitrified rock through a transition zone a few meters thick in which flow layered obsidian alternates with devitrified rock that is commonly highly spherulitic. The devitrified interiors of the flows tend to be light gray containing conspicuous spherulitic crystallization. In places

gas cavities several centimeters across contain lithophysal fillings. The interiors of the flows tend to be crudely flow layered, with the layering subhorizontal just above the basal glass zone, but becoming steeper in upper parts of the lava dome. Near-vertical rib-like masses of flow-layered devitrified rock are commonly exposed high on the domes, where erosion has stripped away the surface mantle of frothy perlite. The steeply dipping flow layering and ramp structures of these domes thus are in contrast with structures in the older lava flows of Wildhorse Canyon and Bailey Ridge.

The porphyritic domes typically do not have well developed central craters, as best shown by South Twin Flat Mountain, although several have slight central depressions that have been breached and accentuated by erosion. This is especially evident for Bearskin Mountain and North Twin Flat Mountain and the northern dome (Fig.2).

Scarcity of bedrock exposures makes relative ages of the domes difficult to determine. North and South Twin Flat Mountains may be among the oldest, and Bearskin Mountain among the youngest of the domes. The K-Ar ages, petrographic and chemical similarities, and the generally similar degree of erosional dissection indicate that the domes are about the same age. The North Twin Flat Mountain dome, is clearly older than the unnamed ridge-capping flow 0.5 km to the north (Fig. 1). A poorly exposed heterolithic lithic-rich pyroclastic breccia intervenes between the upper perlitic breccia of the North Twin Flat Mountain dome and the basal obsidian zone of the overlying rhyolite. Bearskin Mountain and the three domes extending southwest from it appear compositionally homogeneous, consisting of phenocryst-poor rhyolite similar to the rhyolite that overlies the North Twin Flat Mountain dome. The Bearskin

Mountain dome has yielded K-Ar ages on obsidian of $0.58-.78 \pm .07$, and sanidines from obsidian of South Twin Flat Mountain and the unnamed most northerly dome have yielded K-Ar ages of $0.49 \pm .07$ and $0.53 \pm .06$ m.y. Magnetic-polarity determinations for several domes of this group are normal indicating in conjunction with the K-Ar ages that they were erupted during the Brunhes polarity epoch.

The stratigraphic relations and K-Ar ages of rhyolites of the Mineral Mountains, indicate that these rocks were emplaced during a relatively brief period in the Pleistocene, between 0.8 and 0.5 m.y. ago. The Mineral Mountains are flanked on its north and east sides by upper Cenozoic basalt flows (Condie and Barsky, 1972; Hoover, 1974), roughly contemporaneous with a younger than the rhyolite of the Mineral Mountains, and this association of rhyolite and basalt together constitute a bimodal volcanic assemblage of a type that is being recongized widely in the western United States in late Cenozoic time (Christiansen and Lipman, 1972).

A significant question is whether the thermal anomaly of the Roosevelt KGRA is due to proximity to the late Cenozoic volcanic centers in the Mineral Mountains. Roosevelt Hot Springs and other inactive hot springs are clearly located along the mountain-front fault on the west side of the Mineral Mountains, about 2 km west of the nearest exposed rhyolite. The size and shape of the Pleistocene magmatic system underlying the Mineral Mountains cannot be determined with any precision from the surface distribution of rhyolite vents, yet their extent for 15 km along the crest of the range suggests the possibility of a sizable magmatic system at depth. The elongate trend of rhyolite vents possibly might even mark a segment of a large evolving circular igneous structure, such as interpreted for the Coso rhyolite domes in California (Duffield, 1975).

The rhyolites of the Mineral Mountains were extruded along the eroded core of the large Mineral Mountains pluton, itself a late Cenozoic feature of remarkably large size for so young an age. Proximity in space and time suggests that the rhyolite of the Mineral Mountains represents a late stage in evolution of complex magmatic system that had earlier given rise to the granite of the Mineral Mountains. It seems likely, though not probable, that this large complex magmatic system has also been the heat source for the Roosevelt KGRA, with the shallow thermal anomaly enhanced along the range front by deep fault-controlled convective circulation of hot water.

Bulk rock chemistry

Localities of analyzed samples are given in Table 1 and modes of representative volcanics are given in Table 2. Chemical analyses and CIPW norms of the lavas are given in Tables 3 and 4 respectively. Microprobe analyses of glass from obsidians are given in Table 5; CIPW norms of these are provided in Table 6.

The Bailey Ridge and Wildhorse Canyon flows are petrographically similar. They contain less than 0.5 percent total phenocrysts, the majority of which are alkali feldspar. There are trace amounts of oligoclase, biotite, titanomagnetite, and ilmenite. The two flows are virtually identical in chemical composition (Table 3). They are typical silicic alkalic rhyolites, containing about 76.5 percent SiO_2 and just over 9 percent total alkalis. The fresh obsidians contain more fluorine than water; secondarily hydrated pumice from the Bailey Ridge flow contains 2.4 percent total H_2O . The pumice and ash contain several percent of small phenocrysts of quartz, oligoclase, alkali feldspar, biotite, magnetite, ilmenite, sphene, and allanite. This mineral assemblage is generally

Table 1. Localities of analyzed samples of the Mineral Range Volcanics

Sample		
Sample #	Localities	Rock type
MR 74-2	Bailey Ridge flow	Obsidian
MR 74-3	Bailey Ridge flow	Perlite
MR 74-4	Bailey Ridge flow	Pumice
MR 74-7	Big Cedar Cove dome	Rhyolite
MR 74-8	Wild Horse Canyon flow	Obsidian
MR 74-13	Bailey Ridge flow	Obsidian
MR 74-16	Bearskin Mtn. dome	Obsidian
MR 74-18	Pole Line Road	Granite Porphyry
MR 74-19	Pumice Hole Mine	Pumice
MR 74-22	So. Twin Flat Mtn. dome	Obsidian
MR 74-29	Pass Road	Min. Range Granite
MR 75-14	Little Bearskin Mtn. dome	Obsidian
MR 75-18	No. Twin Flat Mtn. dome	Obsidian
MR 75-19	No. Twin Flat Mtn. dome	Rhyolite
MR 75-20	No. Twin Flat Mtn. dome	Obsidian
MR 75-22	Corral Canyon dome	Rhyolite
MR 75-30	Corral Canyon dome	Obsidian

Table 2. MODES OF MINERAL RANGE OBSIDIANS (VOLUME PERCENT)

	74-2	74-3	74-4	74-8	74-13	74-16
glass	90.5	94.2	84.9	85.5	84.2	97.3
sanidine	9.0	3.1	4.0	6.0	1.9	2.3
plagioclase	-	-	0.1	-	-	0.2
biotite	0.1	0.2	1.0	0.8	0.4	-
opaques	-	-	-	1.5	-	-
devitrified glass	0.4	2.4	10.1	6.3	13.5	0.3

Table 3.

Chemical Analyses of Mineral Range Volcanics

	74-2	74-3	74-4	74-7	74-8	74-13	74-16	74-18	74-19	74-29	75-14	75-19	75-20	75-22	75-30
SiO ₂	76.47	76.58	74.51	76.82	76.51	76.50	76.00	76.41	72.87	77.55	76.42	76.46	76.45	75.97	70.13
TiO ₂	0.06	0.06	0.06	0.05	0.06	0.06	0.03	0.05	0.04	0.05	0.04	0.03	0.04	0.10	0.16
Al ₂ O ₃	12.27	12.29	11.98	12.64	12.29	12.30	12.58	12.98	12.46	12.22	12.79	12.57	12.79	12.89	14.14
Fe ₂ O ₃	0.33	0.29	0.33	0.61	0.23	0.32	0.24	0.37	0.19	0.17	0.20	0.41	0.30	0.26	0.68
FeO	0.44	0.48	0.43	0.15	0.51	0.45	0.39	0.31	0.42	0.48	0.38	0.18	0.29	0.46	1.25
MnO	0.04	0.05	0.04	0.05	0.05	0.06	0.07	0.04	0.07	0.02	0.05	0.05	0.05	0.02	0.01
MgO	0.07	0.10	0.10	0.10	0.08	0.08	0.37	0.18	0.17	0.10	0.11	0.08	0.12	0.17	0.58
CaO	0.66	0.60	0.62	0.50	0.65	0.65	0.45	0.31	0.40	0.44	0.44	0.44	0.40	0.91	2.02
Na ₂ O	3.81	3.83	3.56	4.03	3.77	3.77	4.27	3.49	3.64	3.40	4.42	4.35	4.39	3.40	3.44
K ₂ O	5.29	5.24	5.10	5.00	5.28	5.18	4.64	5.23	4.99	4.87	4.72	4.69	4.73	5.19	4.58
P ₂ O ₅	tr	0.01	0.01	0.01	0.01	0.01	0.01	0.01	tr	tr	tr	0.02	0.03	tr	0.06
H ₂ O+	0.10	0.16	2.27	0.02	0.06	0.10	0.26	0.28	3.11	0.05	0.13	0.18	0.10	0.23	2.07
H ₂ O-	0.08	0.04	0.23	0.04	0.06	0.05	0.06	0.10	0.89	0.04	0.01	0.04	-	0.06	0.24
F	0.20	0.14	0.13	-	0.15	0.12	0.25	-	0.23	-	0.34	-	0.33	-	0.03
Sum	99.82	99.87	99.37	-	99.71	99.65	99.62	-	99.48	-	100.05	-	100.02	-	99.40
Less F=0	0.08	0.06	0.05	-	0.06	0.05	0.11	-	0.10	-	0.14	-	0.14	-	0.01
Total	99.74	99.81	99.32	100.02	99.65	99.60	99.51	99.76	99.38	99.39	99.91	99.50	99.88	99.66	99.39

Table 4.

CIPW Norms of Mineral Range Volcanics (Weight %)

	74-2	74-3	74-4	74-7	74-8	74-13	74-16	74-18	74-19	74-29	75-14	75-19	75-20	75-22	75-30
Q	33.17	33.21	33.11	32.22	33.25	33.58	32.43	35.07	31.90	37.72	32.22	32.43	32.49	33.89	26.89
C	-	-	-	-	-	-	0.41	1.04	0.96	0.56	0.41	-	0.45	0.03	0.02
or	31.26	30.96	30.14	29.55	31.20	30.61	27.42	30.91	29.49	28.78	27.89	27.71	27.95	30.67	27.06
ab	32.24	32.41	30.12	34.10	31.90	31.90	36.13	29.53	30.80	28.77	37.40	36.81	37.15	28.77	29.11
an	0.76	0.87	1.65	1.63	1.02	1.34	0.34	1.47	0.30	2.18	-	0.92	-	4.51	9.62
wo	-	-	-	0.04	-	-	-	-	-	-	-	0.21	-	-	-
di-wo	0.44	0.43	0.17	0.29	0.44	0.39	-	-	-	-	-	0.26	-	-	0.01
di-en	0.12	0.13	0.06	0.25	0.10	0.11	-	-	-	-	-	0.20	-	-	-
di-fs	0.35	0.32	0.12	-	0.37	0.31	-	-	-	-	-	0.04	-	-	-
hy-en	0.06	0.12	0.19	-	0.10	0.09	0.92	0.45	0.42	0.25	0.27	-	0.30	0.42	1.44
hy-fs	0.17	0.32	0.37	-	0.37	0.27	0.60	0.26	0.68	0.70	0.56	-	0.31	0.50	1.49
mt	0.48	0.42	0.48	0.50	0.33	0.46	0.35	0.54	0.28	0.25	0.29	0.59	0.43	0.38	0.99
il	0.11	0.11	0.11	0.09	0.11	0.11	0.06	0.09	0.08	0.09	0.08	0.06	0.08	0.19	0.30
hm	-	-	-	0.26	-	-	-	-	-	-	-	-	-	-	-
ap	-	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-	-	-	0.05	0.07	-	0.14
fr	0.41	0.29	0.27	-	0.31	0.25	0.51	-	0.47	-	0.61	-	0.50	-	-
rest	0.18	0.20	2.40	0.06	0.12	0.15	0.31	0.37	3.60	0.10	0.14	0.22	0.10	0.29	2.31
Total	99.75	99.81	99.21	100.02	99.64	99.59	99.50	99.75	98.98	99.40	99.87	99.50	99.83	99.65	99.38

Table 5.

Microprobe analyses of glass in the Mineral Range volcanics

	74-2	74-3	74-4	74-8	74-13	74-16	74-22	75-14	75-18	75-20	75-30
SiO ₂	76.4	76.8	74.2	77.1	76.5	76.0	75.9	76.5	75.8	76.5	74.8
TiO ₂	0.12	0.12	0.12	0.12	0.13	0.06	0.06	0.07	0.08	0.07	0.14
Al ₂ O ₃	12.4	12.4	12.0	12.4	12.4	13.0	13.3	12.6	12.7	12.8	12.9
FeO	0.73	0.72	0.65	0.74	0.75	0.56	0.48	0.53	0.52	0.58	0.82
MnO	0.06	0.06	0.05	0.06	0.05	0.09	0.09	0.11	0.11	0.11	0.05
MgO	0.09	0.08	0.06	0.09	0.09	0.05	0.02	0.04	0.03	0.04	0.12
CaO	0.55	0.56	0.56	0.55	0.54	0.42	0.41	0.38	0.32	0.40	1.06
Na ₂ O	3.67	3.66	3.29	3.58	3.72	4.14	4.02	4.23	4.23	4.29	3.26
K ₂ O	5.10	5.09	4.78	4.95	4.90	4.26	4.83	4.58	4.57	4.53	5.06
F	0.20	0.14	0.08	0.15	0.13	0.25	0.25	0.34	0.33	0.33	0.03
Sum	99.3	99.6	95.9	99.7	99.2	98.8	99.4	99.4	98.8	99.7	98.2
Less O=F	0.1	0.1	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
Total	99.2	99.5	95.9	99.6	99.1	98.7	99.3	99.3	98.7	99.6	98.2

Table 6 . CIPW Norms of Mineral Range Volcanic Glass

	74-2	74-3	74-4	74-8	74-13	74-16	74-22	75-14	75-18	75-20	75-30
Q	34.65	34.90	35.88	36.18	35.02	35.22	34.01	34.03	33.84	33.78	33.83
C	0.38	0.23	0.70	0.53	0.34	1.49	1.47	0.68	0.91	0.79	0.21
or	30.14	30.08	28.25	29.25	28.96	25.17	28.54	27.06	27.01	27.06	29.90
ab	31.05	30.97	27.40	30.29	31.48	35.03	33.57	35.79	35.20	36.30	27.59
an	1.26	1.75	2.19	1.63	1.73	0.25	0.20	-	-	-	5.04
hl	-	-	0.10	-	-	-	0.10	-	0.13	-	-
hy-en	0.22	0.20	0.15	0.22	0.22	0.12	0.05	0.10	0.07	0.10	0.30
hy-fs	0.43	0.55	0.34	0.67	0.45	0.55	0.45	0.59	0.50	0.38	0.62
mt	0.48	0.41	0.43	0.35	0.48	0.32	0.29	0.28	0.32	0.45	0.43
il	0.23	0.23	0.23	0.23	0.25	0.11	0.11	0.13	0.15	0.13	0.27
fr	0.41	0.29	0.16	0.31	0.27	0.51	0.51	0.53	0.45	0.56	0.06
Total	99.26	99.60	95.83	99.66	99.19	98.78	99.32	99.21	98.57	99.55	98.25

characteristic of the youngest rhyolite flows as well. Associated with the pumice ash are a few percent of rhyolitic lithic debris, including devitrified rhyolite, perlite, and sparse obsidian fragments. Phenocrysts in the lithic debris are relatively sparse, generally similar to those in the flows of Bailey Ridge and Wildhorse Canyon.

All the domes contain several percent phenocrysts of quartz, oligoclase, alkali feldspar, biotite, and iron-titanium oxides (Table 2). Trace amounts of sphene and allanite occur in some domes. Hornblende, zircon and allanite are present in the Corral Canyon dome, the southernmost exposure of rhyolitic volcanics. The North and South Twin Flat Mountain domes have 5-8 percent total phenocrysts, distinctly more than any of the others. The obsidian zones of these two domes appear even more phenocryst-rich, because of the presence of small "snowflake" devitrification spots. The flows in upper Wildhorse Canyon and to the north contain only 2-3 percent total phenocrysts.

The porphyritic domes are chemically similar. In comparison with the older flows of Bailey Ridge and Wildhorse Canyon, the domes are slightly but significantly higher in Na_2O and F; they are lower in K_2O and CaO (Table 3).

Analyses of whole rocks and glasses are plotted in terms of SiO_2 - $\text{NaAlSi}_3\text{O}_8$ - KAlSi_3O_8 in Fig. 3. All analyses fall near the minimum melting composition in the "granite system" (Tuttle and Bowen, 1958).

Mineralogy

Modes of the analyzed lavas are given in Table 2. The lavas are composed dominantly of glass with minor amounts of feldspar, biotite, hornblende, titanomagnetite, ilmenite, allanite, apatite, zircon and topaz.

Fig. 3. Chemical analyses of Mineral Range volcanic rocks (solid circles) and glasses (open circles) plotted in terms of normative quartz, albite and orthoclase. Tie lines connect rock and glass analyses from the same sample. See Fig. 7 for location of the ternary minimum in this system.

Feldspar: Both plagioclase and alkali feldspar occur in the Mineral Mountain volcanics. Microprobe analyses are shown in Figs. 4-7. Numerous rocks contain co-existing plagioclase and alkali feldspar; these compositional relations are shown in Fig. 8.

Biotite: Microprobe analyses of biotite are given in Table 7. They are all high in TiO_2 (2.8 - 4.7%) and most contain substantial fluorine (2.6 - 3.5%).

Hornblende: A microprobe analysis of hornblende is given in Table 8. It contains some fluorine but negligible chlorine.

Iron-titanium oxides: Microprobe analyses of iron-titanium oxides are given in Table 9. Analyses are reported for those rocks that contain both titanomagnetite and ilmenite.

Allanite: Allanite is an epidote-type mineral containing substantial amounts of rare earth elements. Analyses of three allanites from the Mineral Range volcanics are given in Table 10 along with an analysis of allanite from the Bishop Tuff, California, for comparison. These are the only two volcanic occurrences we are aware of that contain allanite; the mineral is usually restricted to plutonic rocks of granitic composition. The total rare earth contents of Mineral Range allanites exceed 25 percent.

Sphene: Sphene has been found in several samples and analyses of two are given in Table 11. The sphene contains measurable amounts of the rare earth elements as well as yttrium, niobium, barium and fluorine.

Apatite and topaz: These two minerals occur in accessory amounts in a few lavas. Both are fluorine-rich and indicative of the high fluorine content of the rhyolite magmas. Topaz occurs in vugs in rhyolite and has probably crystallized from the vapor phase.

Figs. 4-7. Analyses of bulk rock, glass and feldspar in individual samples of Quaternary rhyolite from the Mineral Range, Utah. Bulk rock (solid squares) and glass (open squares) compositions are plotted in terms of normative constituents quartz, albite and orthoclase in the upper ternary system. Microprobe analysis of phenocryst (solid circles) and groundmass (open circles) feldspar are plotted in terms of weight percent $\text{CaAl}_2\text{Si}_2\text{O}_8$, $\text{NaAlSi}_3\text{O}_8$ and KAlSi_3O_8 in the lower triangle

which shares a common join, Ab-Or, with the upper system. Coexisting plagioclase and alkali feldspar compositions are connected by tie lines. Values adjacent to tie lines are temperatures ($^{\circ}\text{C}$) for the feldspar pairs calculated from the feldspar thermometer of Stormer (1975). Solid and dashed lines in the upper ternary system represent natural conjugation lines connecting phenocryst and groundmass feldspar compositions with bulk rock and glass compositions. A composite of all the compositional data is given in Fig. 7.

Fig. 8. Compositions of coexisting alkali and plagioclase feldspar together with the host rock composition plotted in the system $\text{CaAl}_2\text{Si}_2\text{O}_8$ (An), $\text{NaAlSi}_3\text{O}_8$ (Ab), KAlSi_3O_8 (or). The locus of rock compositions serves to define the shape of the two feldspar surface.

Fig. 9. Postulated shape of the two feldspar surface at silica saturation. Solid circles are rock compositions in equilibrium with two feldspars; open circles are rock compositions containing only one feldspar.

Table 7. Average microprobe analyses of biotite.

	74-7	74-16	74-19	75-22	75-30	74-3
SiO ₂	38.4	38.4	38.9	36.1	36.5	37.2
TiO ₂	3.26	2.79	3.08	4.57	4.70	3.13
Al ₂ O ₃	12.1	11.7	11.8	13.0	13.7	11.5
FeO	16.0	16.8	16.5	22.0	16.8	16.9
MnO	0.65	0.94	0.79	0.30	0.17	0.73
MgO	14.9	14.3	14.2	11.2	14.7	15.0
CaO	0.04	0.02	0.03	0.04	0.07	0.01
Na ₂ O	0.46	0.40	0.46	0.44	0.47	0.49
K ₂ O	9.01	8.74	9.01	8.41	8.97	9.15
BaO	0.36	0.02	0.04	0.60	0.67	0.06
Cl	0.09	0.09	0.10	0.06	0.05	0.10
F	3.21	2.67	2.57	3.51	0.61	3.13
Sum	99.0	98.2	98.38	100.4	97.4	97.5
-O F,Cl	1.35	1.12	1.08	1.48	0.26	1.3
Total	97.6	97.1	97.3	99.0	97.1	96.2

Table 8. Average microprobe analysis of amphibole.

	<u>75-30</u>
SiO ₂	45.3
TiO ₂	2.04
Al ₂ O ₃	9.30
FeO	13.8
MnO	0.26
MgO	13.5
CaO	11.5
Na ₂ O	1.85
K ₂ O	1.02
Cl	0.04
F	<u>0.33</u>
Sum	98.9
-O=F, Cl	<u>0.14</u>
Total	98.8

Table 9. Average microprobe analyses of iron-titanium oxides

	<u>Ilmenite</u>				<u>Spinel</u>				
	74-3	74-16	74-19	75-22	74-3	74-16	74-19	75-22	75-30
SiO ₂	0.02	0.08	0.03	0.04	0.03	0.08	0.04	0.28	0.59
TiO ₂	42.0	46.5	46.7	44.7	5.00	4.90	4.73	6.45	7.31
Al ₂ O ₃	0.13	0.04	-	0.36	0.93	0.62	0.63	1.52	2.01
Cr ₂ O ₃	-	-	-	0.03	0.03	0.03	0.02	0.07	0.14
V ₂ O ₃	0.82	0.46	0.44	0.49	0.17	0.71	0.72	0.79	0.63
FeO	50.3	44.7	44.8	50.4	86.2	85.8	84.7	83.9	83.3
MnO	3.20	6.40	6.60	2.45	0.90	2.61	2.75	1.25	0.74
MgO	1.50	0.72	0.65	0.32	0.80	0.21	0.20	0.32	0.87
CaO	-	0.01	0.02	0.04	0.09	0.01	0.02	0.04	0.04
ZnO	0.17	0.44	0.12	0.30	0.26	-	0.29	0.25	0.22
Sum	98.14	99.05	99.36	99.13	94.41	94.97	94.10	94.87	95.85
Fe ₂ O ₃	20.6	12.2	11.9	15.0	58.6	58.0	58.3	53.6	52.3
FeO	31.7	33.7	34.1	36.9	33.5	33.0	32.2	35.7	36.2
Total	100.1	100.6	100.6	100.6	100.3	100.9	99.9	100.3	100.7
Mole % USP					14.3	14.2	13.7	19.4	21.5
Mole % Fe ₂ O ₃	20.5	12.0	11.7	15.3					
T°C	740	660	650	735					
-log fO ₂	13.8	16.8	16.9	14.4					

Table 10. Average microprobe analyses of allanite

	74-16	74-19	75-22	Bishop Tuff
SiO ₂	29.7	29.6	30.3	31.20
TiO ₂	1.88	2.04	1.30	2.27
ZrO ₂	0.02	0.03	0.02	
Al ₂ O ₃	10.8	10.5	13.6	10.93
FeO	17.6	18.2	15.8	15.83
MnO	1.80	1.83	0.57	0.46
MgO	1.17	1.13	1.29	1.07
CaO	10.1	10.2	11.5	9.59
Na ₂ O	0.07	0.06	0.04	0.05
K ₂ O	0.06	0.04	0.04	
Ce ₂ O ₃	13.6	13.5	12.6	13.23
La ₂ O ₃	10.2	10.1	6.94	7.58
Pr ₂ O ₃	1.08	1.12	1.39	2.37
Nd ₂ O ₃	1.56	1.64	3.78	3.53
Sm ₂ O ₃	0.71	0.71	0.92	0.37
Gd ₂ O ₃	0.56	0.37	0.45	
Y ₂ O ₃	0.06	0.07	0.12	0.09
Nb ₂ O ₅	0.01	tr	-	
F	0.32	0.32	0.15	0.17
Sum	101.3	101.5	100.8	99.26
-O=F	0.13	0.13	0.06	0.07
Total	101.2	101.3	100.8	99.19*

* includes 0.52 ThO₂ (Hildreth, pers. comm., 1976)

Table 11. Average microprobe analyses of sphene

	74-16	74-19
SiO ₂	30.2	29.9
TiO ₂	34.2	35.8
ZrO ₂	0.14	0.15
Al ₂ O ₃	2.20	1.53
FeO	2.93	2.78
MnO	0.49	0.23
CaO	24.5	24.8
BaO	0.12	0.14
SrO	0.06	0.04
Ce ₂ O ₃	1.13	1.59
La ₂ O ₃	0.28	0.44
Pr ₂ O ₃	0.24	0.26
Nd ₂ O ₃	0.52	0.75
Sm ₂ O ₃	0.13	0.27
Gd ₂ O ₃	0.01	0.06
Y ₂ O ₃	0.89	0.75
Nb ₂ O ₅	0.53	0.32
F	0.64	0.25
Sum	99.21	100.06
-O=F	0.26	0.11
Total	98.95	99.95

Geothermometry

Two mineral thermometers have been employed to determine the temperatures of the magmas giving rise to the volcanics of the Mineral Range. These are the iron-titanium oxide thermometer and oxygen barometer of Buddington and Lindsley (1964) and the two feldspar thermometers of Stormer (1975). Temperatures determined from these thermometers are given in Table 12. Both thermometers indicate that the magmatic temperatures were about, or just slightly less, than 700°C. For rocks of this granitic composition to have been almost totally liquid at these low temperatures requires that the magma have a significant water content.

Geobarometry

Magmatic water fugacities for several lavas may be calculated from the following relationship:

$$\log f_{H_2O} = \frac{7409}{T} + 4.25 + 1/2 \log f_{O_2} + 3 \log x_{Fe^{2+}}^{biot} \\ + \log x_{OH}^{biot} - \log a_{san}^{fs} - \log a_{mt}^{spinel}$$

Solution for four samples are given in Table 13. If one assumes that the fluid phase is solely composed of H₂O then equivalent water pressure may be calculated along with equivalent lithostatic depths for those pressures. These are shown as well in Table 13. The depths of 1.6 km suggest that there may have been several shallow magma chambers present at one time. The depths on the order of 12 km are reasonable depths for

Mineral Equilibration Temperatures

ROCK	Stormer Feldspar Geothermometer			Iron-Titanium Oxides	
	Groundmass Temp	Phenocrysts		Temp	Log f_{O_2}
		Rim Temp	Core Temp		
MR74-2	770°C (1 bar)	—	—	—	—
MR74-3	690°C (1 bar)	—	—	740°C	-13.8
MR74-4	690°C (1 bar)	—	—	—	—
MR74-16	No gms. Plag.	620°C (1 bar)	630°C (1 Kbar) 690°C (5 Kbar)	660°C	-16.8
MR74-19	710°C (1 bar)	710°C (1 bar)	700°C (1 Kbar) 800°C (5 Kbar)	650°C	-16.9
MR75-22	No gms. Plag.	770°C (1 bar)	750°C (1 Kbar) 800°C (5 Kbar)	735°C	-14.4

Table 12

IGNEOUS ROCK BAROMETRY

Sample	$f_{\text{H}_2\text{O}}$ (bars)	$P_{\text{H}_2\text{O}}$ (bars)	P_{total} (bars)	Depth (lithostatic) (Km)
74-3	2240	3110	—	11.9
74-16	360	420	—	1.6
74-19	350	410	—	1.6
75-22	2450	3360	—	12.8
75-30	—	—	2300	8.8

Table 13

the formation of the magmas by partial fusion of quartzo-feldspathic material.

Physical properties of the magmas

Magma density and viscosity have been calculated for each sample, and are given in the computer print-out for each sample as a function of temperature (Appendix 1). Liquid densities are about 2.35 gm/cm^3 at 700°C , and viscosities (Newtonian) are about 6×10^{12} poise at 700°C .

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Appendix

The appendix contains the complete chemical data on wet chemical rock analyses and microprobe analyses of glasses together with a variety of subsidiary petrographic calculations. These include:

1. CIPW Norm in terms of mole & weight %
2. Ternary systems in terms of normative components; mole & weight %.
 - a. Q-Ab-Or
 - b. Q-Ne-Kp
 - c. An-Ab-Or
 - d. A-F-M
3. Ratios; mole or atom & weight %.
 - a. An/Pl
 - b. En/Hy
 - c. Fa/ol
 - d. Na+K/Al
 - e. Fe+Mn/Fe+Mn+Mg
 - f. $\text{Na}_2\text{O}/\text{Na}_2\text{O}+\text{K}_2\text{O}$
 - g. $\text{FeO}/\text{FeO}+\text{Fe}_2\text{O}_3$
 - h. Differentiation index (Thornton and Tuttle, 1960).
4. Density of chemically equivalent liquid (Bottinga and Weill, 1970).
5. Plagioclase thermometer (Kudo and Weill, 1970; Mathez, 1973).
6. Predicted crystallization temperatures for:
 - a. olivine
 - b. Ca-pyroxene after French (1968)
 - c. Plagioclase
7. Molar Volume (Bottinga and Weill, 1970)
8. Estimated heat capacity of equivalent liquid.
9. Ln viscosity of liquid after method of Shaw (1972).

MR 74-2

TOTAL37

CP =

1
$$\text{MOLAR VOL (CAL/BAR)} = .63283 + (.26566 - .04)T \text{ DEG K}$$

DENSITY OF EQUIVALENT LIQ. DRY AND AT 500. BARS P H2O. PRED AB MOLE FRAC									
DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
LN WET	2.346	2.337	2.328	2.319	2.310	2.300	2.291	2.282	2.273
LN DRY	2.351	2.342	2.333	2.324	2.315	2.306	2.297	2.288	2.279

KUDO-WEILL GEOTHERMOMETER

AB DRY	.880	.860	.817	.743	.631	.486	.331	.198	.106
AB .5KB	.873	.842	.783	.685	.545	.382	.232	.123	.059
AB 1.KB	.838	.800	.728	.616	.467	.309	.178	.091	.042
AB 5.KB	.400	.317	.218	.131	.069	.033	.015	.006	.002

REVISED KUDO-WEILL GEOTHERMOMETER

DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
AB DRY	.948	.929	.892	.822	.704	.534	.155	.074	.032
AB .5KB	.718	.691	.629	.535	.201	.128	.074	.040	.021
AB 1.KB	.851	.838	.801	.737	.642	.517	.175	.103	.056

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	29.53	25.61	22.36	19.62	17.28	15.25	13.49	11.93	10.55
LN VISC =40946.19/T DEG K	-12.5419								

DENSITY	SLOPE	INTERCEPT
WET	-.000091	2.4100
DRY	-.000090	2.4136

IDENTIFICATION FIELD READS...

MR 74-3

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN-ERAL	MOLE PCNT	WEIGHT PCNT
SI02	76.58	71.78	.00	82.12	83.00	82.52	Q	31.13	33.21
Ti02	.06	.04	.00	.05	.05	.05	C	.00	.00
ZR02	.00	.00	.00	.00			Z	.00	.00
AL203	12.29	13.58	.00	7.77	7.85	7.80	OR	31.33	30.96
CR203	.00	.00	.00	.00			PL	35.68	33.28
FE203	.29	.20	.00	.12	.12	.12	(AB)	34.81	32.41
FE0	.48	.38	.00	.43	.44	.43	(AN)	.88	.87
MNO	.05	.04		.05	.05	.05	LC	.00	.00
NiO	.00	.00		.00			NE	.00	.00
MGO	.10	.14	.00	.16	.16	.16	KP	.00	.00
CA0	.60	.60	.00	.69	.70	.69	HL	.00	.00
SRO	.00	.00		.00	.00	.00	TH	.00	.00
BA0	.00	.00		.00			AC	.00	.00
NA20	3.83	6.96	.00	3.98	4.02	4.00	NS	.00	.00
K20	5.24	6.27	.00	3.58	3.62	3.60	KS	.00	.00
P205	.01	.01	.00	.00			WO	.00	.00
H20+	.16			.57		.58	DI	.83	.87
H20-	.04						(WO)	.41	.43
S03	.00	.00	.00	.00			(EN)	.14	.13
S	.00		.00	4.10			(FS)	.27	.32
CL	.00		.00	.00			HY	.41	.44
F	.14		.00	.47			(EN)	.14	.12
CO2	.00	.00	.00	.00			(FS)	.27	.32
TOTAL	99.87						OL	.00	.00
-O=F,CL	99.81						(FO)	.00	.00
H20	99.61						(FA)	.00	.00

TERNARY DIAGRAMS			WT PCT MOLPCT			
			(NA+K)/AL	110.56	97.41	CS
			(FE+MN)/(FE+MN+MG)	91.06	81.62	MT
			NA20/(NA20+K20)	42.23	52.63	CM
			FE0/(FE0+FE203)	62.34	78.63	IL
Q	34.39	70.18	AN/PL	2.61	2.46	HM
AB	33.55	15.69	EN/HY	28.15	33.99	TN
OR	32.06	14.13	FA/OL	.00	.00	PF
			DIFNDX	96.58	97.27	RU
						AP
						FR
						PY
						CC

			PRED XLIZ TEMP		SALIC	98.14	97.45
			OLIVINE	954.	FEMIC	1.86	2.16
			CA-PYX	1069.			
			PLAG	1185.	TOTAL	100.00	99.61

CP = 21.261

A	91.25	91.45	MOLAR VOL(CAL/BAR) = .63259 + (.26464-04)T DFG K
F	7.75	6.62	
M	1.01	1.93	

IDENTIFICATION FIELD READS...

MR 74-4

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MINERAL	MOLE PCNT	WEIGHT PCNT
SiO2	74.51	71.96	.00	76.31	83.11	76.64	Q	31.97	33.11
TiO2	.06	.04	.00	.05	.05	.05	C	.00	.00
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	11.98	13.64	.00	7.23	7.88	7.26	OR	31.42	30.14
Cr2O3	.00	.00	.00	.00			PL	35.05	31.77
Fe2O3	.33	.24	.00	.13	.14	.13	(AB)	33.33	30.12
FeO	.43	.35	.00	.37	.40	.37	(AN)	1.72	1.65
MnO	.04	.03		.03	.04	.03	LC	.00	.00
NiO	.00	.00		.00			NE	.00	.00
MgO	.10	.14	.00	.15	.17	.15	KP	.00	.00
CaO	.62	.64	.00	.68	.74	.68	HL	.00	.00
SrO	.00	.00		.00	.00	.00	TH	.00	.00
BaO	.00	.00		.00			AC	.00	.00
Na2O	3.56	6.67	.00	3.53	3.85	3.55	NS	.00	.00
K2O	5.10	6.28	.00	3.33	3.63	3.35	KS	.00	.00
P2O5	.01	.01	.00	.00			WO	.00	.00
H2O+	2.27			7.75		7.79	DI	.35	.35
H2O-	.23						(WO)	.17	.17
SO3	.00	.00	.00	.00			(EN)	.07	.06
S	.00		.00	4.11			(FS)	.10	.12
CL	.00		.00	.00			HY	.55	.56
F	.13		.00	.42			(EN)	.22	.19
CO2	.00	.00	.00	.00			(FS)	.33	.37
TOTAL	99.37						OL	.00	.00
-O=F,CL	99.32						(FO)	.00	.00
H2O	96.82						(FA)	.00	.00

BINARY DIAGRAMS				WT PCT	MOLPCT		WT PCT	MOLPCT
				(NA+K)/AL	108.43	94.96	CS	.00
				(FE+MN)/(FE+MN+MG)	90.81	81.15	MT	.36
				NA2O/(NA2O+K2O)	41.11	51.48	CM	.00
				FeO/(FeO+Fe2O3)	56.58	74.33	IL	.09
				AN/PL	5.19	4.90	HM	.00
				EN/HY	33.60	39.93	TN	.00
				FA/OL	.00	.00	PF	.00
				DIFNDX	93.37	96.72	RU	.00
							AP	.02
							FR	.20
							PY	.00
							CC	.00

			PRED XLIZ TEMP		SALIC	98.44	95.01
			OLIVINE	925.	FEMIC	1.56	1.80
			CA-PYX	1090.			
			PLAG	1227.	TOTAL	100.00	96.81

$$CP = 21.263$$

	90.97	91.38		
	7.98	6.59		
	1.05	2.03		

MOLAR VOL(CAL/BAR) = .63312 + (.26230-04)T DEG K

DENSITY OF EQUIVALENT LIQ. DRY AND AT 5000. BARS P H2O. PRED AB MOLE FRAC									
DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
EN WET	2.260	2.268	2.256	2.243	2.231	2.219	2.207	2.194	2.182
EN DRY	2.351	2.342	2.333	2.324	2.315	2.306	2.297	2.289	2.280

KUDO-WEILL GEOTHERMOMETER

AB DRY	.881	.861	.817	.743	.632	.487	.331	.198	.106
AB .5KB	.873	.843	.783	.685	.546	.382	.232	.123	.059
AB 1.KB	.839	.801	.729	.616	.468	.310	.178	.091	.042
AB 5.KB	.401	.318	.219	.131	.069	.033	.015	.006	.002

REVISED KUDO-WEILL GEOTHERMOMETER

DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
AB DRY	.948	.930	.892	.823	.705	.534	.155	.074	.032
AB .5KB	.719	.692	.629	.535	.202	.128	.074	.040	.021
AB 1.KB	.852	.838	.802	.738	.642	.517	.175	.103	.056

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	29.70	25.77	22.50	19.74	17.39	15.36	13.58	12.02	0.63
LN VISC =	41140.99/T DEG K -12.5711								

DENSITY	SLOPE	INTERCEPT
WET	-.000122	2.3657
DRY	-.000089	2.4127

IDENTIFICATION FIELD READS...
MR 74-7

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN-ERAL	MOLE PCNT	WEI HT P NT
SiO2	76.82	71.61	.00	83.00	83.06	83.00	Q	30.97	33.22
TiO2	.05	.04	.00	.04	.04	.04	C	.00	.00
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.64	13.89	.00	8.05	8.05	8.05	OR	29.73	29.55
Cr2O3	.00	.00	.00	.00			PL	38.07	35.73
Fe2O3	.61	.43	.00	.25	.25	.25	(AB)	36.42	34.10
FeO	.15	.12	.00	.14	.14	.14	(AN)	1.65	1.63
MnO	.05	.04		.05	.05	.05	LC	.00	.00
NiO	.00	.00		.00			NE	.00	.00
MgO	.10	.14	.00	.16	.16	.16	KP	.00	.00
CaO	.50	.50	.00	.58	.58	.58	HL	.00	.00
SrO	.00	.00		.00	.00	.00	TH	.00	.00
BaO	.00	.00		.00			AC	.00	.00
Na2O	4.03	7.28	.00	4.22	4.22	4.22	HS	.00	.00
K2O	5.00	5.95	.00	3.45	3.45	3.45	KS	.00	.00
P2O5	.01	.01	.00	.00			WO	.04	.04
H2O+	.02			.07		.07	DI	.56	.54
H2O-	.04						(WO)	.28	.29
SO3	.00	.00	.00	.00			(EN)	.28	.25
S	.00		.00	4.11			(FS)	.00	.00
CL	.00		.00	.00			HY	.00	.00
F	.00		-.00	.00			(EN)	.00	.00
CO2	.00	.00	.00	.00			(FS)	.00	.00
TOTAL	100.02						OL	.00	.00
-O=F,CL	100.02						(FO)	.00	.00
H2O	99.96						(FA)	.00	.00

ERNARY DIAGRAMS			WT PCT	MOLPCT		
		(NA+K)/AL	106.73	95.26	CS	.00
		(FE+MN)/(FE+MN+MG)	90.61	80.79	MT	.36
		NA2O/(NA2O+K2O)	44.63	55.06	CM	.00
		FeO/(FeO+Fe2O3)	19.74	35.34	IL	.07
		AN/PL	4.57	4.32	HM	.19
		EN/HY	.00	.00	TN	.00
		FA/OL	.00	.00	PF	.00
		DIFNDX	96.86	97.12	RU	.00
					AP	.02
					FR	.00
					PY	.00
					CC	.00

		PRED XLIZ TEMP		SALIC	98.77	98.50
		OLIVINE	956.	FEMIC	1.23	1.46
		CA-PYX	1074.			
		PLAG	1188.	TOTAL	100.00	99.96

CP = 21.264

A	91.30	93.37				
F	7.68	4.67				
M	1.01	1.96				

MOLAR VOL(CAL/BAR) = .63518 + (.26072-.04)T D G K

DENSITY OF EQUIVALENT LIQ. DRY AND AT 500. BARS P H2O. PRED AB MOLE FRAC									
DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1.00.
DEN WLT	2.347	2.338	2.329	2.320	2.312	2.303	2.294	2.285	2.276
DEN DRY	2.348	2.339	2.330	2.321	2.313	2.304	2.295	2.286	2.277

KUDO-WEILL GEOTHERMOMETER

AB DRY	.911	.896	.861	.800	.704	.568	.407	.255	.141
AB .5KB	.906	.882	.834	.751	.625	.462	.294	.162	.080
AB 1.KB	.879	.848	.789	.690	.549	.383	.231	.121	.058
AB 5.KB	.483	.393	.280	.173	.094	.045	.020	.008	.003

REVISED KUDO-WEILL GEOTHERMOMETER

DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1.00.
AB DRY	.962	.948	.920	.866	.768	.613	.202	.099	.044
AB .5KB	.781	.757	.702	.615	.498	.169	.100	.055	.028
AB 1.KB	.889	.878	.849	.796	.713	.597	.455	.137	.076

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	29.65	25.72	22.46	19.71	17.36	15.32	13.55	11.99	9.61
LN VISC =	41081.45/T DEG K -12.5622								

DENSITY	SLOPE	INTERCEPT
WLT	-.000088	2.4085
DRY	-.000088	2.4092

IDENTIFICATION FIELD READS...

MR 74-8

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN-ERAL	MOLE PCNT	WEI HT P NT
SiO2	76.51	71.80	.00	82.38	82.99	82.81	Q	31.21	33.25
TiO2	.06	.04	.00	.05	.05	.05	C	.00	.00
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.29	13.60	.00	7.80	7.86	7.84	OR	31.61	31.20
Cr2O3	.00	.00	.00	.00			PL	35.34	32.92
Fe2O3	.23	.16	.00	.09	.09	.09	(AB)	34.30	31.90
FeO	.51	.40	.00	.46	.46	.46	(AN)	1.03	1.02
MnO	.05	.04		.05	.05	.05	LC	.00	.00
NiO	.00	.00		.00			NE	.00	.00
MgO	.08	.11	.00	.13	.13	.13	KP	.00	.00
CaO	.65	.65	.00	.75	.76	.75	HL	.00	.00
SiO	.00	.00		.00	.00	.00	TH	.00	.00
BaO	.00	.00		.00			AC	.00	.00
Na2O	3.77	6.36	.00	3.94	3.96	3.96	NS	.00	.00
K2O	5.28	6.32	.00	3.63	3.65	3.65	KS	.00	.00
P2O5	.01	.01	.00	.00			WO	.00	.00
H2O+	.06			.22		.22	DI	.85	.90
H2O-	.06						(WO)	.42	.44
SO3	.00	.00	.00	.00			(EN)	.11	.10
S	.00		.00	4.10			(FS)	.31	.37
CL	.00		.00	.00			HY	.43	.47
F	.15		.00	.51			(EN)	.11	.10
CO2	.00	.00	.00	.00			(FS)	.32	.37
TOTAL	99.71						OL	.00	.00
-O=F, CL	99.65						(FO)	.00	.00
H2O	99.53						(FA)	.00	.00

BINARY DIAGRAMS				WT PCT	MOLPCT		
			(NA+K)/AL	110.38	96.96	CS	.00
			(FE+MN)/(FE+MN+MG)	92.51	84.33	MT	.24
			NA2O/(NA2O+K2O)	41.66	52.04	CM	.00
			FeO/(FeO+Fe2O3)	68.92	83.13	IL	.08
34.51	70.30		AN/PL	3.10	2.92	HM	.00
33.11	15.46		EN/HY	21.20	26.12	TN	.00
32.38	14.24		FA/OL	.00	.00	PF	.00
			DIFNDX	96.35	97.11	RU	.00
						AP	.02
						FR	.22
63.66	81.37					PY	.00
17.94	9.70					CC	.00
18.40	8.93						

		PRED XLIZ TEMP		SALIC	98.15	97.37
		OLIVINE	959.	FEMIC	1.85	2.15
		CA-PYX	1067.			
		PLAG	1183.	TOTAL	100.00	99.52

CP = 21.265

91.69	91.74		
7.50	6.70	MOLAR VOL (CAL/BAR) =	.63240 + (.26496-04) T D G K
.81	1.56		

DENSITY OF EQUIVALENT LIQ. DRY AND AT 5000. BARS P H2O. PRED AB NO E FRAC

DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
LN WET	2.349	2.340	2.331	2.322	2.313	2.304	2.295	2.286	2.277
LN DRY	2.351	2.342	2.333	2.324	2.315	2.306	2.297	2.289	2.280

UDO-WEILL GEOTHERMOMETER

AB DRY	.881	.861	.818	.744	.633	.488	.333	.199	.107
AB .5KB	.873	.843	.784	.686	.547	.384	.233	.124	.059
AB 1.KB	.859	.802	.730	.617	.469	.311	.179	.091	.043
AB 5.KB	.402	.319	.220	.132	.070	.033	.015	.006	.002

REVISED KUDO-WEILL GEOTHERMOMETER

DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
AB DRY	.943	.930	.892	.823	.706	.535	.156	.074	.032
AB .5KB	.719	.692	.630	.536	.202	.128	.075	.041	.021
AB 1.KB	.852	.839	.802	.739	.644	.518	.176	.103	.056

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	29.60	25.67	22.41	19.67	17.32	15.29	13.52	11.96	10.58
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LN VISC = 41018.36/T DEG K - 12.5528

DENSITY	SLOPE	INTERCEPT
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WET	-.000091	2.4128
DRY	-.000090	2.4140

IDENTIFICATION FIELD READS...
MR 74-13

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MINERAL	MOLE PCNT	WEIGHT PCNT
SiO2	76.50	71.86	.00	82.41	83.05	82.75	O	31.55	33.58
TiO2	.06	.04	.00	.05	.05	.05	C	.00	.00
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.30	13.62	.00	7.81	7.87	7.84	OR	31.04	30.61
Cr2O3	.00	.00	.00	.00			PL	35.70	33.24
Fe2O3	.32	.23	.00	.13	.13	.13	(AB)	34.33	31.00
FeO	.45	.35	.00	.41	.41	.41	(AN)	1.36	1.34
MnO	.06	.05		.05	.06	.05	LC	.00	.00
NiO	.00	.00		.00			NE	.00	.00
MgO	.06	.11	.00	.13	.13	.13	KP	.00	.00
CaO	.65	.65	.00	.75	.76	.75	HL	.00	.00
SrO	.00	.00		.00	.00	.00	TH	.00	.00
BaO	.00	.00		.00			AC	.00	.00
Na2O	3.77	6.87	.00	3.94	3.97	3.95	NS	.00	.00
K2O	3.18	6.21	.00	3.56	3.59	3.57	KS	.00	.00
F2O5	.01	.01	.00	.00			WO	.00	.00
H2O+	.10			.36		.36	DI	.76	.81
H2O-	.05						(WO)	.38	.39
SO3	.00	.00	.00	.00			(EN)	.12	.11
S	.00		.00	4.11			(FS)	.26	.31
CL	.00		.00	.00			HY	.33	.36
F	.12		.00	.41			(EN)	.10	.09
CO2	.00	.00	.00	.00			(FS)	.23	.27
TOTAL	99.65						OL	.00	.00
-O=F,CL	99.60						(FO)	.00	.00
H2O	99.45						(FA)	.00	.00

TERNARY DIAGRAMS			WT PCT	MOLPCT	
		(Na+K)/Al	109.02	96.00	CS
		(Fe+Mn)/(Fe+Mn+Mg)	92.78	84.85	MT
		Na2O/(Na2O+K2O)	42.12	52.52	CM
		FeO/(FeO+Fe2O3)	58.44	75.76	IL
		AN/PL	4.04	3.81	HM
		EN/HY	25.75	31.31	TN
		FA/OL	.00	.00	PF
		DIFNDX	96.09	96.92	RU
					AP
					FR
					PY
					CC

	65.91	81.53
IL	17.98	9.70
P	16.10	8.77

	2.10	2.04
B	49.96	51.45
R	47.94	46.51

PRED XLIZ TEMP
OLIVINE 961.
CA-PYX 1070.
PLAG 1184.

SALIC 98.28 97.43
FEMIC 1.72 2.01
TOTAL 100.00 99.45

CP = 21.265

A	91.33	91.87
F	7.86	6.56
M	.82	1.57

MOLAR VOL(CAL/BAR) = .63287 + (.26280-04)T DEG K

DENSITY OF EQUIVALENT LIQ. DRY AND AT 5000. BARS P H2O. PRED AB MOLE FRAC

DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
LN WET	2.348	2.339	2.330	2.321	2.312	2.302	2.293	2.284	2.275
LN DRY	2.351	2.342	2.333	2.324	2.315	2.306	2.298	2.289	2.280

KUDO-WEILL GEOTHERMOMETER

AB DRY	.881	.861	.818	.744	.633	.488	.333	.199	.107
AB .5KB	.874	.844	.784	.686	.547	.384	.233	.124	.059
AB 1.KB	.840	.802	.730	.618	.469	.311	.179	.091	.043
AB 5.KB	.402	.319	.220	.132	.070	.033	.015	.006	.002

REVISED KUDO-WEILL GEOTHERMOMETER

DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
AB DRY	.948	.930	.893	.824	.706	.535	.156	.074	.032
AB .5KB	.720	.693	.631	.537	.203	.128	.075	.041	.021
AB 1.KB	.853	.839	.802	.739	.644	.518	.176	.103	.056

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	29.65	25.72	22.45	19.70	17.35	15.32	13.55	11.90	10.61
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LN VISC = 41079.56/T DEG K - 12.5619

DENSITY	SLOPE	INTERCEPT
WET	-.000091	2.4111
DRY	-.000089	2.4131

IDENTIFICATION FIELD READS...

NR 74-16

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN- ERAL	MOLE PCNT	WEIGHT PCNT
SiO2	76.00	71.26	.00	81.10	82.57	81.80	Q	30.41	32.43
TiO2	.03	.02	.00	.02	.02	.02	C	.45	.41
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.58	13.90	.00	7.91	8.05	7.98	OR	27.75	27.42
Cr2O3	.00	.00	.00	.00			PL	39.16	36.47
Fe2O3	.24	.17	.00	.10	.10	.10	(AB)	38.81	36.13
FeO	.39	.31	.00	.35	.35	.35	(AN)	.34	.34
MnO	.07	.06		.06	.06	.06	LC	.00	.00
NiO	.00	.00		.00			NE	.00	.00
MgO	.37	.52	.00	.59	.60	.59	KP	.00	.00
CaO	.45	.45	.00	.51	.52	.52	HL	.00	.00
SR	.00	.00		.00	.00	.00	TH	.00	.00
BA	.00	.00		.00			AC	.00	.00
Na2O	4.27	7.76	.00	4.42	4.50	4.40	NS	.00	.00
K2O	4.64	5.55	.00	3.15	3.22	3.19	KS	.00	.00
P2O5	.01	.01	.00	.00			WO	.00	.00
H2O+	.26			.93		.93	DI	.00	.00
H2O-	.06						(WO)	.00	.00
SO3	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.07			(FS)	.00	.00
CL	.00		.00	.00			HY	1.55	1.52
F	.25		.00	.84			(EN)	1.03	.92
CO2	.00	.00	.00	.00			(FS)	.51	.60
TOTAL	99.62						OL	.00	.00
-O=F,CL	99.51						(FO)	.00	.00
H2O	99.19						(FA)	.00	.00

		WT PCT	MOLPCT		
TERTIARY DIAGRAMS		(NA+K)/AL	105.43	95.76	MT
		(FE+MN)/(FE+MH+MG)	70.18	50.65	CM
		Na2O/(Na2O+K2O)	47.92	58.31	IL
		FeO/(FeO+Fe2O3)	61.90	78.32	HM
		AN/PL	.93	.88	TN
		EN/HY	60.62	66.92	PE
		FA/OL	.00	.00	RU
		DIFNDX	95.98	96.97	AP
					FR
					PY
					CC

		PRED XLIZ TEMP	SALIC	97.77	96.73
		OLIVINE	986.	FEMIC	2.23
		CA-PYX	1081.		
		PLAG	1185.	TOTAL	100.00
					99.19

CP = 21.238

A	39.91	88.00			
F	6.36	5.16			
M	3.73	6.84			

MOLAR VOL(CAL/BAR) = .63118 + (.26036-.04)T DEG K

DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
LN WET	2.344	2.334	2.325	2.316	2.307	2.297	2.288	2.279	2.269
LN DRY	2.352	2.343	2.334	2.325	2.316	2.308	2.299	2.290	2.281

UDO-WEILL GEOTHERMOMETER

AB DRY	.922	.909	.878	.823	.734	.604	.443	.284	.160
AB .5KB	.917	.896	.853	.778	.659	.499	.326	.184	.092
AB 1.KB	.893	.866	.812	.721	.585	.419	.258	.138	.066
AB 5.KB	.519	.428	.311	.195	.107	.052	.023	.010	.004

REVISED KUDO-WEILL GEOTHERMOMETER

DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
AB DRY	.967	.955	.930	.882	.793	.648	.455	.113	.051
AB .5KB	.804	.783	.732	.649	.535	.190	.114	.063	.033
AB 1.KB	.903	.893	.867	.819	.743	.632	.492	.155	.087

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC 29.30 25.40 22.17 19.45 17.12 15.11 13.36 11.81 10.44

LN VISC =40680.13/T DEG K -12.5020

DENSITY	SLOPE	INTERCEPT
WET	-.000093	2.4083
DRY	-.000088	2.4136

IDENTIFICATION FIELD READS...
MR 74-18

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN-ERAL	MOLE PCNT	WEIGHT PCNT
SiO2	76.41	71.84	.00	82.35	83.19	82.35	Q	32.97	35.07
TiO2	.05	.04	.00	.04	.04	.04	C	1.15	1.04
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.98	14.38	.00	8.24	8.35	8.24	OR	31.36	30.91
Cr2O3	.00	.00	.00	.00			PL	33.31	31.00
Fe2O3	.37	.26	.00	.15	.15	.15	(AB)	31.81	29.53
FeO	.31	.24	.00	.28	.28	.28	(AN)	1.50	1.47
MnO	.04	.03		.04	.04	.04	LC	.00	.00
NiO	.00	.00		.00			NE	.00	.00
MgO	.18	.25	.00	.29	.29	.29	KP	.00	.00
CaO	.31	.31	.00	.36	.36	.36	HL	.00	.00
SR0	.00	.00		.00	.00	.00	TH	.00	.00
BaO	.00	.00		.00			AC	.00	.00
Na2O	3.49	6.36	.00	3.65	3.68	3.65	NS	.00	.00
K2O	5.23	6.27	.00	3.60	3.63	3.60	KS	.00	.00
P2O5	.01	.01	.00	.00			WO	.00	.00
H2O+	.28			1.01		1.01	DI	.00	.00
H2O-	.10						(WO)	.00	.00
SO3	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.16			(FS)	.00	.00
CL	.00		.00	.00			HY	.72	.70
F	.00		-.00	.00			(EH)	.50	.45
CO2	.00	.00	.00	.00			(FS)	.22	.26
TOTAL	99.76						OL	.00	.00
-O=F,CL	99.76						(FO)	.00	.00
H2O	99.38						(FA)	.00	.00

			WT PCT	MOLPCT		
TERTIARY DIAGRAMS			(NA+K)/AL	100.89	87.84	CS
			(FE+MN)/(FE+MN+MG)	83.02	68.05	MT
			Na2O/(Na2O+K2O)	40.02	50.35	CM
			FeO/(FeO+Fe2O3)	45.59	65.06	IL
			AN/PL	4.75	4.49	HM
			EN/HY	63.71	69.76	TN
			FA/OL	.00	.00	PF
			DIFNDX	95.51	96.15	RU
						AP
						FR
						PY
						CC

Q	64.86	82.17	PRED XLIZ TEMP		SALIC	98.79	98.02
AB	16.75	8.98	OLIVINE	948.	FEMIC	1.21	1.36
OR	18.39	8.85	CA-PYX	1072.			
			PLAG	1209.	TOTAL	100.00	99.38

CP = 21.252

Q	91.02	90.97					
AB	7.10	5.39	MOLAR VOL(CAL/BAR) = .63590 + (.25833-04)T DEG F				
OR	1.88	3.63					

DENSITY OF EQUIVALENT LIQ. DRY ADD AT 500. PARS P H2O. PRED AB HOLE FRAC	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
EN WET	2.336	2.326	2.317	2.308	2.299	2.290	2.281	2.272	2.263
EN DRY	2.349	2.340	2.331	2.322	2.314	2.305	2.296	2.288	2.279

KUDO-WEILL GEOTHERMOMETER

AB DRY	.939	.927	.902	.855	.776	.656	.498	.330	.191
AB .5KB	.935	.917	.881	.816	.708	.554	.376	.218	.111
AB 1.KB	.916	.893	.846	.766	.640	.474	.302	.166	.081
AB 5.KB	.584	.491	.365	.235	.131	.064	.029	.012	.005

REVISED KUDO-WEILL GEOTHERMOMETER

AB DRY	.974	.965	.944	.904	.828	.697	.509	.136	.062
AB .5KB	.842	.823	.777	.701	.591	.454	.138	.077	.040
AB 1.KB	.923	.915	.892	.851	.784	.682	.546	.185	.105

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	30.09	26.11	22.81	20.02	17.64	15.59	13.79	12.21	10.81
LN VISC = 41581.76/T DEG K - 12.6373									

DENSITY	SLOPE	INTERCEPT
WET	-.000091	2.3994
DRY	-.000087	2.4095

IDENTIFICATION FIELD READS...

NR 74-19

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN-ERAL	MOLE PCNT	WEIGHT PCNT
SiO2	72.87	71.27	.00	73.44	82.69	73.99	O	31.21	31.90
TiO2	.04	.03	.00	.03	.03	.03	C	1.11	.96
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.46	14.36	.00	7.40	8.33	7.46	OR	31.13	29.49
Cr2O3	.00	.00	.00	.00			PL	34.83	31.10
Fe2O3	.19	.14	.00	.07	.08	.07	(AB)	34.51	30.80
FeO	.42	.34	.00	.35	.40	.36	(AN)	.32	.30
MnO	.07	.06		.06	.07	.06	LC	.00	.00
HfO	.00	.00		.00			NE	.00	.00
NaO	.17	.25	.00	.26	.29	.26	KP	.00	.00
CaO	.40	.42	.00	.43	.49	.44	HL	.00	.00
SR0	.00	.00		.00	.00	.00	TH	.00	.00
BAO	.00	.00		.00			AC	.00	.00
NA2O	3.64	6.90	.00	3.56	4.00	3.58	NS	.00	.00
K2O	4.99	6.23	.00	3.21	3.61	3.23	KS	.00	.00
P2O5	.00	.00	.00	.00			WO	.00	.00
H2O+	3.11			10.45		10.53	DI	.00	.00
H2O-	.89						(WO)	.00	.00
SO3	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.11			(FS)	.00	.00
CL	.00		.00	.00			HY	1.10	1.10
F	.23		.00	.73			(EN)	.50	.42
CO2	.00	.00	.00	.00			(FS)	.60	.68
TOTAL	99.48						OL	.00	.00
-O=F,CL	99.38						(FO)	.00	.00
H2O	95.38						(FA)	.00	.00

TERNARY DIAGRAMS			WT PCT MOLPCT			
		(NA+K)/AL	103.76	91.40	MT	.21 .28
		(FE+MN)/(FE+MN+MG)	83.36	68.60	CM	.00 .00
WT PCT MOLPCT		NA2O/(NA2O+K2O)	42.18	52.58	IL	.06 .08
		FE0/(FE0+FE2O3)	68.85	83.09	HM	.00 .00
34.61 70.39		AN/PL	.97	.91	TN	.00 .00
B 33.41 15.57		EN/HY	38.43	45.06	PF	.00 .00
R 31.98 14.04		FA/OL	.00	.00	RU	.00 .00
		DIFNDX	92.19	96.85	AP	.00 .00
					FR	.36 .47
63.73 81.40					PY	.00 .00
E 18.10 9.78					CC	.00 .00
P 18.18 8.82						

		PRED XLIZ TEMP		SALIC	98.28	93 45
		OLIVINE	930.	FEMIC	1.72	1 93
N .50 .48		CA-PYX	1100.			
B 50.84 52.32		PLAG	1249.	TOTAL	100.00	95.38
R 48.67 47.19						

CP = 21.266

A	91.71	90.85
F	6.48	5.72
M	1.81	3.43

MOLAR VOL(CAL/BAR) = .63383 + (.26405-04)T D.G K

DENSITY OF EQUIVALENT LIO. DRY AND AT 5000. PARS P H2O. PRED AB MO E FRAC

DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1 00.
WET	2.255	2.242	2.228	2.215	2.202	2.188	2.175	2.161	2.148
DRY	2.352	2.343	2.334	2.325	2.316	2.307	2.298	2.289	2.280

KUDO-WEILL GEOTHERMOMETER

AB DRY	.927	.913	.882	.828	.739	.608	.446	.286	.161
AB .5KB	.922	.901	.858	.783	.664	.503	.329	.185	.092
AB 1.KB	.900	.872	.818	.727	.591	.423	.260	.139	.067
AB 5.KB	.555	.441	.320	.200	.109	.053	.024	.010	.004

REVISED KUDO-WEILL GEOTHERMOMETER

DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1 00.
AB DRY	.969	.957	.933	.885	.797	.652	.458	.114	.051
AB .5KB	.814	.792	.740	.657	.541	.193	.115	.064	.033
AB 1.KB	.908	.898	.871	.824	.747	.636	.495	.156	.087

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	29.69	25.75	22.49	19.73	17.60	15.35	13.57	12.01	10.62
LN VISC = 41124.89/T DEG K	-12.5687								

DENSITY	SLOPE	INTERCEPT
WET	-.000134	2.3490
DRY	-.000089	2.4142

IDENTIFICATION FIELD READS...

PK 74-29

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN-ERAL	MOLE PCNT	WEIGHT PCNT
SiO2	77.55	73.19	.00	83.87	34.02	83.87	O	35.60	37.72
TiO2	.05	.04	.00	.04	.04	.04	C	.62	.56
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.22	13.59	.00	7.79	7.80	7.79	OR	29.32	28.78
Cr2O3	.00	.00	.00	.00			PL	33.33	30.95
Fe2O3	.17	.12	.00	.07	.07	.07	(AB)	31.11	28.77
FeO	.48	.38	.00	.43	.43	.43	(AN)	2.22	2.18
MnO	.02	.02		.02	.02	.02	LC	.00	.00
NiO	.00	.00		.00			NE	.00	.00
MgO	.10	.14	.00	.16	.16	.16	KP	.00	.00
CaO	.44	.44	.00	.51	.51	.51	IL	.00	.00
SiO	.00	.00		.00	.00	.00	TH	.00	.00
NaO	.00	.00		.00			AC	.00	.00
Na2O	3.40	6.22	.00	3.57	3.57	3.57	NS	.00	.00
K2O	4.87	5.86	.00	3.36	3.37	3.36	KS	.00	.00
P2O5	.00	.00	.00	.00			WO	.00	.00
H2O+	.05			.18		.18	DI	.00	.00
H2O-	.04						(WO)	.00	.00
SO3	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.22			(FS)	.00	.00
CL	.00		.00	.00			HY	.88	.94
F	.00		.00	.00			(EN)	.28	.25
CO2	.00	.00	.00	.00			(FS)	.60	.70
TOTAL	99.39						OL	.00	.00
-O=F,CL	99.39						(FO)	.00	.00
H2O	99.30						(FA)	.00	.00

TERTIARY DIAGRAMS			WT PCT	MOLPCT		
		(NA+K)/AL	101.51	88.90	CS	.00
		(FE+MN)/(FE+MN+MG)	89.38	78.56	MT	.18
		NA2O/(NA2O+K2O)	41.11	51.48	CM	.00
		FeO/(FeO+Fe2O3)	73.85	86.26	IL	.07
Q	39.60	74.66			HM	.00
AB	30.20	13.05			TN	.00
OR	30.21	12.30			PF	.00
		AN/PL	7.05	6.67	RU	.00
		EN/HY	26.37	32.00	AP	.00
		FA/OL	.00	.00	FR	.00
		DIFNDX	95.27	96.03	PY	.00
Q	66.48	83.18			CC	.00
NE	16.36	8.66				
KP	17.17	8.16				

		PRED XLIZ TEMP		SALIC	98.87	98.01
		OLIVINE	962.	FEMIC	1.13	1.29
AN	3.65	3.55				
AB	48.17	49.65				
OR	48.18	46.79				
		CA-PYX	1073.			
		PLAG	1194.			
				TOTAL	100.00	99.30

CP = 21.219

A	91.69	91.24		
F	7.21	6.63		
M	1.11	2.12		
			MOLAR VOL(CAL/BAR) =	.63418 + (.24757-04)T D G K

DENSITY OF EQUIVALENT LIQ. DRY AND AT 500. BARS P H2O. PRED AB MO E FRAC

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
DEN WET	2.343	2.335	2.326	2.318	2.309	2.301	2.292	2.284	2.275
DEN DRY	2.346	2.337	2.329	2.320	2.312	2.304	2.295	2.287	2.278

KUDO-WEILL GEOTHERMOMETER

XAB DRY	.903	.887	.851	.787	.688	.551	.391	.244	.134
XAB .5KB	.896	.871	.821	.736	.607	.445	.281	.154	.076
XAB 1.KB	.867	.836	.774	.673	.531	.367	.219	.115	.055
XAB 5.KB	.456	.371	.263	.162	.087	.042	.019	.008	.003

REVISED KUDO-WEILL GEOTHERMOMETER

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
XAB DRY	.958	.943	.913	.856	.754	.597	.419	.294	.141
XAB .5KB	.762	.739	.684	.596	.479	.359	.244	.152	.077
XAB 1.KB	.878	.869	.837	.783	.698	.580	.424	.280	.142

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	30.60	26.56	23.21	20.39	17.98	15.90	14.08	12.47	1.05
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LN VISC = 42162.00/T DEG K - 12.7243

DENSITY	SLOPE	INTERCEPT
WET	-.000085	2.4024
DRY	-.000084	2.4042

IDENTIFICATION FIELD READS...

MR-75-14 GLASS

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN- ERAL	MOLE PCNT	WEIGHT PCNT
SiO2	76.50	71.86	.00	82.25	83.21	83.21	O	31.97	34.03
TiO2	.07	.05	.00	.06	.06	.06	C	.76	.68
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.60	13.95	.00	7.98	8.08	8.08	OR	27.44	27.06
Cr2O3	.00	.00	.00	.00			PL	38.52	35.79
Fe2O3	.19	.13	.00	.08	.08	.08	(AB)	38.52	35.79
FeO	.36	.28	.00	.32	.33	.33	(AN)	.00	.00
MnO	.11	.09		.10	.10	.10	LC	.00	.00
NiO	.00	.00		.00			NE	.00	.00
MgO	.04	.06	.00	.06	.06	.06	KP	.00	.00
CaO	.38	.38	.00	.44	.44	.44	HL	.00	.00
SiO	.00	.00		.00	.00	.00	TH	.00	.00
BaO	.00	.00		.00			AC	.00	.00
Na2O	4.25	7.70	.00	4.41	4.46	4.46	NS	.00	.00
K2O	4.58	5.49	.00	3.14	3.18	3.18	KS	.00	.00
P2O5	.00	.00	.00	.00			WO	.00	.00
H2O+	.00			.00		.00	DI	.00	.00
H2O-	.00						(WO)	.00	.00
SO3	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.15			(FS)	.00	.00
CL	.00		.00	.00			HY	.62	.69
F	.34		.25	1.16			(EH)	.11	.10
CO2	.00	.00	.00	.00			(FS)	.51	.59
TOTAL	99.40						OL	.00	.00
-O=F,CL	99.26						(FO)	.00	.00
H2O	99.26						(FA)	.00	.00

TERNARY DIAGRAMS			WT PCT MOLPCT			
		(NA+K)/AL	104.07	94.57	CS	.00 .00
		(FE+MN)/(FE+MN+MG)	95.38	90.01	MT	.20 .28
WT PCT MOLPCT		Na2O/(Na2O+K2O)	48.01	58.40	CM	.00 .00
		FeO/(FeO+Fe2O3)	65.45	60.81	IL	.10 .13
O	35.13	70.79			HM	.00 .00
AB	36.94	17.06	AN/PL	.00 .00	TN	.00 .00
OR	27.93	12.15	EN/HY	14.38 18.08	PF	.00 .00
			FA/OL	.00 .00	RU	.00 .00
			DIFNDX	96.89 97.94	AP	.00 .00
					FR	.38 .53
					PY	.00 .00
					CC	.00 .00

		PRED XLIZ TEMP		SALIC	98.70	97.58
		OLIVINE	993.	FEMIC	1.30	1.63
AN	.00	CA-PYX	1078.			
AB	56.94	PLAG	1180.	TOTAL	100.00	99.21
OR	43.06					

$$CP = 21.242$$

A	95.72	94.20	MOLAR VOL(CAL/BAR) = .63387 + (.25520-04)T DEG K
F	5.85	5.00	
M	.43	.80	

DENSITY OF EQUIVALENT LIQ. DRY AND AT 5000. BARS P H2O. PRED AB MO E FRAC									
T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
DEN WET	2.345	2.336	2.327	2.318	2.309	2.300	2.291	2.282	2.273
DEN DRY	2.349	2.340	2.332	2.323	2.314	2.305	2.296	2.287	2.278

KUDO-WEILL GEOTHERMOMETER

XAB DRY	.927	.914	.885	.832	.746	.618	.458	.297	.169
XAB .5KB	.922	.902	.861	.789	.673	.514	.340	.193	.097
XAB 1.KB	.900	.874	.822	.733	.600	.434	.270	.145	.070
XAB 5.KB	.530	.445	.325	.205	.113	.055	.025	.010	.004

REVISED KUDO-WEILL GEOTHERMOMETER

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
XAB DRY	.969	.958	.934	.888	.803	.662	.470	.119	.053
XAB .5KB	.815	.794	.745	.664	.550	.200	.120	.067	.035
XAB 1.KB	.909	.899	.874	.828	.755	.646	.507	.163	.092

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC 29.53 25.61 22.36 19.62 17.28 15.25 13.48 11.93 10.55
 LN VISC =40944.00/T DEG K -12.5416

DENSITY	SLOPE	INTERCEPT
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WET	-.000090	2.4084
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DRY	-.000088	2.4111
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IDENTIFICATION FIELD READS...
NR 75-19

SPECIES	INPUT WT	CATION PCT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN-ERAL	MOLE PCNT	WEIGHT PCNT
SiO2	76.46	71.57	.00	82.53	83.07	82.54	Q	30.36	32.43
TiO2	.03	.02	.00	.02	.02	.02	C	.45	.41
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.57	13.87	.00	8.00	8.05	8.00	OR	28.00	27.71
Cr2O3	.00	.00	.00	.00			PL	40.41	37.73
Fe2O3	.41	.29	.00	.17	.17	.17	(AB)	39.48	36.81
FeO	.18	.14	.00	.16	.16	.16	(AN)	.93	.92
MnO	.05	.04		.05	.05	.05	LC	.00	.00
NiO	.00	.00		.00			NE	.00	.00
MgO	.08	.11	.00	.13	.13	.13	KP	.00	.00
CaO	.44	.44	.00	.51	.51	.51	HL	.00	.00
SrO	.00	.00		.00	.00	.00	TH	.00	.00
BaO	.00	.00		.00			AC	.00	.00
Na2O	4.35	7.90	.00	4.55	4.56	4.55	NS	.00	.00
K2O	4.69	5.60	.00	3.23	3.25	3.23	KS	.00	.00
P2O5	.02	.02	.00	.01			WO	.20	.21
H2O+	.16			.65		.65	DI	.51	.50
H2O-	.04						(WO)	.25	.26
SO3	.00	.00	.00	.00			(EN)	.22	.20
S	.00		.00	4.11			(FS)	.03	.04
CL	.00		.00	.00			HY	.00	.00
F	.00		-.00	.00			(EN)	.00	.00
CO2	.00	.00	.00	.00			(FS)	.00	.00
TOTAL	99.50						OL	.00	.00
-O=F,CL	99.50						(FO)	.00	.00
H2O	99.28						(FA)	.00	.00

			WT PCT	MOLPCT				
TERNARY DIAGRAMS			(NA+K)/AL	107.03	97.31	MT	.43	.59
			(FE+MN)/(FE+MN+MG)	90.61	80.79	CM	.00	.00
WT PCT MOLPCT			NA2O/(NA2O+K2O)	48.12	58.50	IL	.04	.06
			FeO/(FeO+Fe2O3)	30.51	49.39	HM	.00	.00
Q	33.45	69.22	AN/PL	2.44	2.31	TN	.00	.00
AB	37.97	18.00	EN/HY	.00	.00	PF	.00	.00
OR	28.59	12.77	FA/OL	.00	.00	RU	.00	.00
			DIFNDX	96.95	97.84	AP	.04	.05
						FR	.00	.00
Q	63.19	80.95				PY	.00	.00
NE	20.57	11.14				CC	.00	.00
KP	16.24	7.91						

		PRED XLIZ TEMP	SALIC	99.22	98.28
		CLIVINE			
AN	1.41	1.36	FEMIC	1.23	1.41
AB	56.24	57.70			
OR	42.35	40.93			
		PLAG			
			TOTAL	100.45	99.69

CP = 21.252

A	95.10	94.44		
F	6.08	3.99	MOLAR VOL(CAL/BAR) =	.63441 + (.25922-04)T DEG K
M	.82	1.56		

DENSITY OF EQUIVALENT LIQ. DRY AND AT 5000. BARS P H2O. PRED AB MOLE FRAC										
T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.	
DEN WET	2.340	2.331	2.322	2.313	2.304	2.295	2.286	2.277	2.268	
DEN DRY	2.346	2.337	2.329	2.320	2.311	2.302	2.294	2.285	2.276	

KUDO-WEILL GEOTHERMOMETER

XAB DRY	.924	.910	.880	.826	.739	.610	.451	.291	.165
XAB .5KB	.916	.898	.856	.782	.665	.506	.333	.188	.094
XAB 1.KB	.895	.869	.816	.726	.592	.426	.264	.142	.068
XAB 5.KB	.523	.433	.316	.199	.109	.054	.024	.010	.004

REVISED KUDO-WEILL GEOTHERMOMETER

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
XAB DRY	.967	.956	.931	.884	.797	.654	.462	.116	.052
XAB .5KB	.807	.786	.736	.655	.541	.195	.117	.065	.034
XAB 1.KB	.904	.895	.869	.823	.748	.639	.499	.159	.089

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	29.68	25.74	22.48	19.72	17.37	15.34	13.57	12.00	10.62
LN VISC	=41111.74/T DEG K -12.5668								

DENSITY	SLOPE	INTERCEPT
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WET	-.000090	2.4036
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DRY	-.000087	2.4073
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IDENTIFICATION FIELD READS...
MR 75-20

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN- ERAL	MOLE PCNT	WEIGHT PCNT
SiO2	76.45	71.29	.00	81.60	82.83	82.53	Q	30.30	32.49
TiO2	.04	.03	.00	.03	.03	.03	C	.42	.45
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.79	14.06	.00	8.05	8.17	8.14	OR	28.13	27.95
Cr2O3	.00	.00	.00	.00			PL	39.69	37.15
Fe2O3	.30	.21	.00	.12	.12	.12	(AB)	39.69	37.15
FeO	.29	.23	.00	.26	.26	.26	(AN)	.00	.00
MnO	.05	.04		.05	.05	.05	LC	.00	.00
MgO	.00	.00		.00			NE	.00	.00
MgO	.12	.17	.00	.19	.19	.19	KP	.00	.00
CaO	.40	.40	.00	.46	.46	.46	HL	.00	.00
SpO	.00	.00		.00	.00	.00	TH	.00	.00
BaO	.00	.00		.00			AC	.00	.00
Na2O	4.39	7.94	.00	4.54	4.61	4.59	NS	.00	.00
K2O	4.73	5.63	.00	3.22	3.27	3.26	KS	.00	.00
P2O5	.03	.02	.00	.01			WO	.00	.00
H2O+	.10			.36		.36	DI	.00	.00
H2O-	.00						(WO)	.00	.00
SO3	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.10			(FS)	.00	.00
CL	.00		.00	.00			HY	.60	.61
F	.33		.25	1.11			(EN)	.33	.30
CO2	.00	.00	.00	.00			(FS)	.26	.31
TOTAL	100.02						OL	.00	.00
-O=F,CL	99.88						(FO)	.00	.00
H2O	99.78						(FA)	.00	.00

TERNARY DIAGRAMS			WT PCT		MOLPCT					
		(NA+K)/AL	106.12	96.49			CS	.00	.00	
		(FE+MN)/(FE+MN+MG)	86.75	74.06			MT	.32	.43	
	WT PCT	MOLPCT	HA2O/(HA2O+K2O)	48.14	58.52			CM	.00	.00
			FeO/(FeO+Fe2O3)	49.15	68.24			IL	.06	.08
Q	33.29	69.07	AN/PL	.00	.00			HM	.00	.00
AB	38.07	18.10	EN/HY	48.96	55.76			TN	.00	.00
OR	28.64	12.83	FA/OL	.00	.00			PF	.00	.00
			DIFNDX	97.59	98.11			RU	.00	.00
								AP	.06	.07
								FR	.36	.50
Q	63.10	80.89						PY	.00	.00
NE	20.62	11.18						CC	.00	.00
KP	16.28	7.93								

		PRED XLIZ TEMP		SALIC	98.61	98.03
		OLIVINE	973.	FEMIC	1.39	1.69
AN	.00	CA-PYX	1078.			
AB	57.06	PLAG	1184.			
OR	42.94			TOTAL	100.00	99.73

CP = 21.254

A	92.78	93.16		
F	6.00	4.55	MOLAR VOL (CAL/BAR) =	.63331 + (.26093-04) T D G K
M	1.22	2.29		

DENSITY OF EQUIVALENT LIQ. DRY AND AT 5000. BARS P H2O. PRED AB MOLE FRAC									
T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
DEN WET	2.345	2.336	2.327	2.318	2.309	2.300	2.291	2.282	2.273
DEN DRY	2.348	2.339	2.331	2.322	2.313	2.304	2.295	2.286	2.278

KUDO-WEILL GEOTHERMOMETER

XAB DRY	.932	.920	.893	.843	.761	.638	.479	.315	181
XAB .5KB	.928	.909	.871	.802	.691	.535	.359	.206	104
XAB 1.KB	.907	.883	.834	.749	.620	.454	.287	.156	076
XAB 5.KB	.556	.465	.343	.219	.122	.060	.027	.011	005

REVISED KUDO-WEILL GEOTHERMOMETER

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
XAB DRY	.971	.961	.939	.896	.816	.680	.491	.128	.058
XAB .5KB	.827	.807	.760	.682	.571	.218	.130	.072	.038
XAB 1.KB	.915	.906	.883	.840	.770	.665	.528	.175	.099

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC 29.57 25.65 22.39 19.65 17.30 15.26 13.51 11.95 10.57
 LN VISC =40989.92/T DEG K -12.5485

DENSITY	SLOPE	INTERCEPT
WET	-.000090	2.4078
DRY	-.000088	2.4098

IDENTIFICATION FIELD READS...
MR 75-22

SPECIES	INPUT WT	CATION PCT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN-ERAL	MOLE PCNT	WEIGHT PCNT
SiO2	75.97	71.48	.00	81.91	82.60	81.91	Q	31.89	33.89
TiO2	.10	.07	.00	.08	.08	.08	C	.03	.03
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.89	14.30	.00	8.19	8.26	8.19	OR	31.15	30.67
Cr2O3	.00	.00	.00	.00			PL	35.60	33.28
Fe2O3	.26	.18	.00	.11	.11	.11	(AB)	31.02	28.77
FeO	.46	.36	.00	.41	.42	.41	(AH)	4.59	4.51
MnO	.02	.02		.02	.02	.02	LC	.00	.00
NiO	.00	.00		.00			NE	.00	.00
MgO	.17	.24	.00	.27	.28	.27	KP	.00	.00
CaO	.91	.92	.00	1.05	1.06	1.05	HL	.00	.00
SR0	.00	.00		.00	.00	.00	TH	.00	.00
LaO	.00	.00		.00			AC	.00	.00
HA20	3.40	6.20	.00	3.55	3.58	3.55	NS	.00	.00
K20	5.19	6.23	.00	3.57	3.60	3.57	KS	.00	.00
P205	.00	.00	.00	.00			WO	.00	.00
H20+	.23			.83		.83	DI	.00	.00
H20-	.06						(WO)	.00	.00
SO3	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.12			(FS)	.00	.00
CL	.00		.00	.00			HY	.91	.93
F	.00		.00	.00			(EH)	.48	.42
CO2	.00	.00	.00	.00			(FS)	.43	.50
TOTAL	99.66						OL	.00	.00
-O=F,CL	99.66						(FO)	.00	.00
H20	99.37						(FA)	.00	.00

TERNARY DIAGRAMS			WT PCT MOLPCT	
		(NA+K)/AL	100.13	86.97
		(FE+MN)/(FE+MN+MG)	84.40	70.21
		NA2O/(NA2O+K2O)	39.58	49.89
		FeO/(FeO+Fe2O3)	63.89	79.73
Q	36.32	71.95	AN/PL	13.56 12.88
AB	30.82	13.99	EN/HY	45.76 52.57
OR	32.86	14.05	FAZOL	.00 .00
			DIFNDX	93.33 94.06

Q	64.63	82.03
NE	16.70	8.96
KP	18.67	9.00

AN	7.06	6.87
AB	44.99	46.46
OR	47.96	46.66

PRED XLIZ TEMP
OLIVINE 950.
CA-PYX 1075.
PLAG 1204.

SALIC 98.68 97.87
FEMIC 1.32 1.49
TOTAL 100.00 99.37

CP = 21.296

A	90.61	89.98
F	7.59	6.57
M	1.79	3.45

MOLAR VOL(CAL/BAR) = .63274 + (.26066-04)T D G K

DENSITY OF EQUIVALENT LIQ. DRY AND AT 5000. PARS P H2O. PRED AB MO E FRAC									
T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
DEN WET	2.348	2.339	2.330	2.321	2.312	2.302	2.293	2.284	2.275
DEN DRY	2.356	2.347	2.338	2.329	2.320	2.312	2.303	2.294	2.285

KUDO-WEILL GEOTHERMOMETER

XAB DRY	.856	.829	.775	.686	.561	.411	.265	.151	.078
XAB .5KB	.847	.808	.736	.622	.472	.313	.180	.092	.043
XAB 1.KB	.808	.760	.674	.548	.396	.248	.136	.067	.031
XAB 5.KB	.351	.268	.178	.102	.053	.025	.011	.004	.002

REVISED KUDO-WEILL GEOTHERMOMETER

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
XAB DRY	.936	.912	.864	.778	.640	.457	.118	.054	.023
XAB .5KB	.673	.638	.567	.465	.158	.097	.055	.029	.015
XAB 1.KB	.825	.803	.757	.680	.572	.227	.134	.076	.041

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	29.72	25.78	22.51	19.75	17.40	15.36	13.59	12.02	10.64
LN VISC =41153.58/T DEG K -12.5730									

DENSITY	SLOPE	INTERCEPT
WET	-.000092	2.4129
DRY	-.000088	2.4176

NY 75-30

TOTAL	99.36
-O=F, CL	99.36
H2O	97.05

Q	32.37	68.25
BE	35.04	16.93
OR	32.58	14.83
Q	62.50	80.58
BE	18.96	10.35
KP	16.52	9.07

AN	14.62	14.24
AB	44.24	45.72
OR	41.14	40.05

CP = 21.450

A	76.16	74.28
F	16.33	15.45
M	5.51	10.27

$$\text{MOLAR VOL (CAL/BAR)} = .62505 + (.27139-04)T \text{ D G K}$$

DENSITY OF EQUIVALENT LIQ. DRY AND AT 500. BARS P H2O. PRED AB MO, E FRAC
T DEG C 700. 800. 900. 1000. 1100. 1200. 1300. 1400. 1500.
DEN WLT 2.297 2.285 2.273 2.261 2.248 2.236 2.224 2.212 2.199
DEN DRY 2.395 2.386 2.377 2.367 2.358 2.348 2.339 2.329 2.320

KUDO-WEILL GEOTHERMOMETER

XAB DRY .846 .805 .732 .622 .477 .323 .192 .102 .050
XAB .5KB .837 .782 .689 .553 .390 .238 .127 .061 .027
XAB 1.KB .795 .729 .622 .477 .319 .184 .094 .044 .019
XAB 5.KB .335 .238 .147 .079 .038 .017 .007 .003 .001

REVISED KUDO-WEILL GEOTHERMOMETER

T DEG C 700. 800. 900. 1000. 1100. 1200. 1300. 1400. 1500.
XAB DRY .931 .898 .835 .725 .560 .169 .081 .035 .014
XAB .5KB .655 .600 .510 .188 .119 .069 .037 .019 .009
XAB 1.KB .811 .776 .712 .615 .489 .160 .093 .050 .026

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC 27.25 23.58 20.54 17.97 15.73 13.88 12.22 10.77 9.48
LN VISC = 38348.70/T DEG K -12.1523

DENSITY	SLOPE	INTERCEPT
WLT	-.000123	2.3834
DRY	-.000094	2.4614

IDENTIFICATION FIELD READS...
 NR 74-2 GLASS

SPECIES	INPUT WT PCT	CATION PCT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN- ERAL	MOLE PCNT	WEIGHT PCNT
SiO2	76.40	72.00	.00	82.59	83.16	83.16	Q	32.66	34.65
TiO2	.12	.09	.00	.10	.10	.10	C	.42	.38
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.46	13.77	.00	7.90	7.95	7.95	OR	30.66	30.14
Cr2O3	.00	.00	.00	.00			PL	34.82	32.32
Fe2O3	.33	.23	.00	.13	.14	.14	(AB)	33.53	31.05
FeO	.43	.34	.00	.39	.39	.39	(AN)	1.29	1.26
MnO	.06	.05		.05	.06	.06	LC	.00	.00
NiO	.00	.00		.00			NE	.00	.00
MgO	.09	.13	.00	.15	.15	.15	KP	.00	.00
CaO	.55	.56	.00	.64	.64	.64	HL	.00	.00
SR0	.00	.00		.00	.00	.00	TH	.00	.00
BA0	.00	.00		.00			AC	.00	.00
Na2O	3.67	6.71	.00	3.85	3.87	3.87	HS	.00	.00
K2O	5.10	6.13	.00	3.52	3.54	3.54	KS	.00	.00
P2O5	.00	.00	.00	.00			WO	.00	.00
H2O+	.00			.00		.00	DI	.00	.00
H2O-	.00						(WO)	.00	.00
SO3	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.13			(FS)	.00	.00
CL	.00		.00	.00			HY	.62	.65
F	.20		.00	.68			(EN)	.25	.22
CO2	.00	.00	.00	.00			(FS)	.37	.43
TOTAL	99.35						OL	.00	.00
-O=F,CL	99.27						(FO)	.00	.00
H2O	99.27						(FA)	.00	.00

ERNARY DIAGRAMS				WT PCT	MOLPCT			
				(NA+K)/AL	106.00	93.20	CS	.00
				(FE+MN)/(FE+MN+MG)	91.85	83.08	MT	.35
				Na2O/(Na2O+K2O)	41.85	52.24	CM	.00
				FeO/(FeO+Fe2O3)	56.58	74.33	IL	.17
				AN/PL	3.91	3.70	HM	.00
				EN/HY	34.25	40.63	TH	.00
				FA/OL	.00	.00	PF	.00
				DIFNDX	95.85	96.85	RU	.00
							AP	.00
							FR	.30
							PY	.00
							CC	.00

			PRED XLIZ TEMP	SALIC	98.56	97.49
			OLIVINE	FEMIC	1.44	1.77
			CA-PYX			
			PLAG			
				TOTAL	100.00	99.26

CP = 21.257

A	91.16	91.68				
F	7.90	6.51				
M	.94	1.81				

$$\text{MOLAR VOL (CAL/BAR)} = .63362 + (.25955 - .04)T \text{ DEG K}$$

DENSITY OF EQUIVALENT LIQ. DRY AND AT 500. BARS P H2O. PRED AB MOLE FRAC

DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
LN WET	2.351	2.342	2.333	2.324	2.315	2.307	2.298	2.289	2.280
LN DRY	2.351	2.342	2.333	2.324	2.315	2.307	2.298	2.289	2.280

KUDO-WEILL GEOTHERMOMETER

AB DRY	.896	.878	.858	.770	.665	.523	.365	.223	.121
AB .5KB	.889	.862	.807	.716	.582	.418	.259	.140	.068
AB 1.KB	.858	.824	.757	.650	.504	.342	.200	.103	.049
AB 5.KB	.438	.351	.245	.149	.079	.038	.017	.007	.003

REVISED KUDO-WEILL GEOTHERMOMETER

DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
AB DRY	.955	.939	.906	.843	.734	.570	.175	.084	.037
AB .5KB	.748	.722	.663	.572	.453	.145	.085	.046	.024
AB 1.KB	.870	.858	.824	.765	.675	.553	.197	.117	.064

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	29.84	25.89	22.61	19.84	17.48	15.44	13.66	12.02	10.70
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LN VISC = 41297.37/T DEG K - 12.5946

DENSITY	SLOPE	INTERCEPT
WET	-.000088	2.4120
DRY	-.000088	2.4120

IDENTIFICATION FIELD READS...
MR-74-J GLASS

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN- ERAL	MOLE PCNT	WEIGHT PCNT
SiO2	76.80	72.13	.00	82.84	83.24	83.24	Q	32.78	34.90
TiO2	.12	.08	.00	.10	.10	.10	C	.25	.23
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.40	15.73	.00	7.88	7.92	7.92	OR	30.49	30.08
Cr2O3	.00	.00	.00	.00			PL	35.11	32.72
Fe2O3	.28	.20	.00	.11	.11	.11	(AB)	33.33	30.97
FeO	.47	.37	.00	.42	.43	.43	(AN)	1.78	1.75
MnO	.06	.05		.05	.06	.06	LC	.00	.00
MgO	.00	.00		.00			NE	.00	.00
MgO	.06	.11	.00	.13	.13	.13	KP	.00	.00
CaO	.56	.56	.00	.65	.65	.65	HL	.00	.00
SrO	.00	.00		.00	.00	.00	TH	.00	.00
CaO	.00	.00		.00			AC	.00	.00
Na2O	3.66	6.67	.00	3.83	3.85	3.85	NS	.00	.00
K2O	5.09	6.10	.00	3.50	3.52	3.52	KS	.00	.00
P2O5	.00	.00	.00	.00			WO	.00	.00
H2O+	.00			.00		.00	DI	.00	.00
H2O-	.00						(WO)	.00	.00
SO3	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.14			(FS)	.00	.00
CL	.00		.00	.00			HY	.69	.74
F	.14		.00	.48			(EN)	.22	.20
CO2	.00	.00	.00	.00			(FS)	.47	.55
TOTAL	99.66						OL	.00	.00
-O=F,CL	99.60						(FO)	.00	.00
H2O	99.60						(FA)	.00	.00

TERNARY DIAGRAMS			WT PCT MOLPCT		
			(Na+K)/Al	105.76	92.98
			(Fe+Mn)/(Fe+Mn+Mg)	92.64	84.59
	WT PCT	MOLPCT	Na2O/(Na2O+K2O)	41.83	52.22
			FeO/(FeO+Fe2O3)	62.67	78.86
Q	36.38	71.98	AN/PL	5.36	5.07
AB	32.28	14.63	EN/HY	26.77	32.45
OR	31.35	13.39	FA/OL	.00	.00
			DIFNDX	95.95	96.61
Q	64.70	82.04			
NE	17.49	9.38			
KP	17.81	8.58			

			PRED XL1Z TEMP		SALIC	98.64	97.93
			OLIVINE	961.	FEMIC	1.36	1.67
AN	2.79	2.71	CA-PYX	1070.			
AB	49.31	50.80	PLAG	1188.	TOTAL	100.00	99.60
OR	47.89	46.49					

CP = 21.253

A	91.34	91.67		
F	7.33	6.72	NOLAR VOL(CAL/BAR) =	.63340 + (.25840-04)T DEG K
M	.84	1.61		

DENSITY OF EQUIVALENT LIQ. DRY AND AT 500. BARS P H2O. PRED AB MOLE FRAC

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
DEN WET	2.350	2.342	2.333	2.324	2.315	2.307	2.298	2.289	2.280
DEN DRY	2.350	2.342	2.333	2.324	2.315	2.307	2.298	2.289	2.280

KUDO-WEILL GEOTHERMOMETER

XAB DRY	.895	.875	.855	.766	.660	.517	.359	.219	.119
XAB .5KB	.886	.858	.803	.711	.576	.412	.254	.137	.066
XAB 1.KB	.855	.820	.752	.645	.498	.336	.197	.101	.048
XAB 5.KB	.431	.345	.241	.146	.078	.037	.017	.007	.003

REVISED KUDO-WEILL GEOTHERMOMETER

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
XAB DRY	.953	.937	.903	.840	.729	.564	.172	.082	.036
XAB .5KB	.743	.717	.657	.565	.447	.142	.083	.045	.023
XAB 1.KB	.867	.854	.820	.761	.670	.547	.194	.114	.063

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	29.91	25.95	22.67	19.90	17.53	15.48	13.70	12.12	10.73
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LN VISC = 41380.55/T DEG K - 12.6071

DENSITY	SLOPE	INTERCEPT
WET	-.000087	2.4116
DRY	-.000087	2.4116

IDENTIFICATION FIELD READS...
MR-74-4 CLASS

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN- ERAL	MOLE PCNT	WEIGHT PCNT
SiO2	74.20	72.61	.00	83.26	83.59	83.59	Q	35.11	35.88
TiO2	.12	.09	.00	.10	.10	.10	C	.80	.70
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.00	13.84	.00	7.94	7.97	7.97	OR	29.84	28.25
Cr2O3	.00	.00	.00	.00			PL	33.03	29.59
Fe2O3	.30	.22	.00	.13	.13	.13	(AB)	30.72	27.40
FeO	.38	.31	.00	.36	.36	.36	(AN)	2.32	2.19
MnO	.05	.04		.05	.05	.05	LC	.00	.00
NiO	.00	.00		.00			NE	.00	.00
MgO	.06	.09	.00	.10	.10	.10	KP	.00	.00
CaO	.56	.59	.00	.67	.68	.68	HL	.10	.10
SrO	.00	.00		.00	.00	.00	TH	.00	.00
Bar	.00	.00		.00			AC	.00	.00
Na2O	3.29	6.24	.00	3.58	3.59	3.59	NS	.00	.00
K2O	4.78	5.97	.00	3.42	3.43	3.43	KS	.00	.00
P2O5	.00	.00	.00	.00			WO	.00	.00
H2O+	.00			.00		.00	DI	.00	.00
H2O-	.00						(WO)	.00	.00
SO3	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.19			(FS)	.00	.00
CL	.06		.00	.11			HY	.48	.49
F	.08		.00	.28			(EN)	.18	.15
CO2	.00	.00	.00	.00			(FS)	.31	.34
TOTAL	95.88						OL	.00	.00
-O=F,CL	95.83						(FO)	.00	.00
H2O	95.83						(FA)	.00	.00

TERNARY DIAGRAMS			WT PCT MOLPCT						
			(NA+K)/AL	100.91	88.21	CS	.00	.00	
			(FE+MN)/(FE+MN+MG)	93.76	86.76	MT	.33	.43	
			Na2O/(Na2O+K2O)	40.77	51.13	CM	.00	.00	
			FeO/(FeO+Fe2O3)	55.88	73.79	IL	.18	.23	
Q	39.20	74.35	AN/PL	7.41	7.01	HM	.00	.00	
AB	29.93	13.01	EN/HY	30.24	36.29	TN	.00	.00	
OR	30.56	12.64	FA/OL	.00	.00	PF	.00	.00	
			DIFNDX	91.52	95.67	RU	.00	.00	
						AP	.00	.00	
Q	68.25	83.05				FR	.12	.16	
NE	16.22	8.60				PY	.00	.00	
KP	17.54	8.35				CC	.00	.00	

			PRED XLIZ TEMP		SALIC	98.89	94.51
			OLIVINE	1056.	FEMIC	1.11	1.32
AN	3.79	3.69	CA-PYX	1077.			
AB	47.37	46.86	PLAG	1175.			
OR	48.84	47.46			TOTAL	100.00	95.83

CP = 21.249

A	91.60	92.30
F	7.72	6.37
M	.68	1.32

MOLAR VOL(CAL/BAR) = .63453 + (.25150-04)T DEG K

DENSITY OF EQUIVALENT LIO. DRY AND AT 500. BARS P H2O. PRED AB MOLE FRAC									
DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
LN WLT	2.349	2.340	2.332	2.323	2.315	2.306	2.298	2.289	2.281
LN DRY	2.349	2.340	2.332	2.323	2.315	2.306	2.298	2.289	2.281

KUDO-WEILL GEOTHERMOMETER

AB DRY	.885	.866	.823	.750	.640	.495	.339	.204	.109
AB .5KB	.878	.848	.790	.693	.555	.391	.238	.127	.061
AB 1.KB	.845	.808	.737	.625	.477	.317	.183	.093	.044
AB 5.KB	.412	.327	.226	.135	.072	.034	.015	.006	.003

REVISED KUDO-WEILL GEOTHERMOMETER

DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
AB DRY	.950	.932	.896	.828	.712	.542	.159	.076	.033
AB .5KB	.727	.700	.638	.544	.207	.132	.077	.042	.021
AB 1.KB	.858	.844	.808	.745	.651	.525	.180	.106	.058

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	50.35	26.34	23.02	20.21	17.82	15.75	13.94	12.35	10.94
LN VISC =41878.09/T DEG K -12.6817									

DENSITY	SLOPE	INTERCEPT
WLT	-.000085	2.4093
DRY	-.000085	2.4083

IDENTIFICATION FIELD READS...
NR-74-8 GLASS

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN- ERAL	MOLE PCNT	WEIGHT PCNT
SiO2	77.10	72.45	.00	83.01	83.43	83.43	Q	34.01	36.18
TiO2	.12	.08	.00	.10	.10	.10	C	.58	.53
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.37	13.70	.00	7.85	7.89	7.89	OR	29.67	29.25
Cr2O3	.00	.00	.00	.00			PL	34.27	31.92
Fe2O3	.24	.17	.00	.10	.10	.10	(AB)	32.62	30.29
FeO	.52	.41	.00	.47	.47	.47	(AN)	1.65	1.63
MnO	.06	.05		.05	.05	.05	LC	.00	.00
HfO	.00	.00		.00			NE	.00	.00
MgO	.09	.13	.00	.14	.15	.15	KP	.00	.00
CaO	.55	.55	.00	.63	.64	.64	HL	.00	.00
SiO	.00	.00		.00	.00	.00	TH	.00	.00
BaO	.00	.00		.00			AC	.00	.00
Na2O	5.58	6.52	.00	3.74	3.76	3.76	NS	.00	.00
K2O	4.95	5.93	.00	3.40	3.42	3.42	KS	.00	.00
P2O5	.00	.00	.00	.00			WO	.00	.00
H2O+	.00			.00		.00	DI	.00	.00
H2O-	.00						(WO)	.00	.00
SO3	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.16			(FS)	.00	.00
CL	.00		.00	.00			HY	.83	.89
F	.15		.00	.51			(EN)	.25	.22
CO2	.00	.00	.00	.00			(FS)	.57	.67
TOTAL	99.73						OL	.00	.00
-O=F,CL	99.67						(FO)	.00	.00
H2O	99.67						(FA)	.00	.00

TERNARY DIAGRAMS			WT PCT	MOLPCT			
		(NA+K)/AL	103.33	90.92	CS	.00	.00
		(FE+MN)/(FE+MN+MG)	91.93	83.24	MT	.25	.35
		NA2O/(NA2O+K2O)	41.97	52.36	CM	.00	.00
		FeO/(FeO+Fe2O3)	68.42	82.81	IL	.17	.23
Q	37.80	73.19			HM	.00	.00
AB	31.64	14.04			TN	.00	.00
OR	30.56	12.77			PF	.00	.00
		AN/PL	5.11	4.83	RU	.00	.00
		EN/HY	25.07	30.54	AP	.00	.00
		FA/OL	.00	.00	FR	.22	.31
		DIFNDX	95.73	96.29	PY	.00	.00
					CC	.00	.00

		PRED XLIZ TEMP		SALIC	98.53	97.88
		OLIVINE	961.	FEMIC	1.47	1.78
AN	2.67	2.59				
AE	49.52	51.01				
OR	47.82	46.40				
		PLAG	1190.	TOTAL	100.00	99.66
CP = 21.243						

A	90.94	90.95
F	8.10	7.21
M	.96	1.84

$$\text{MOLAR VOL (CAL/BAR)} = .63330 + (.25378-04)T \text{ DEG K}$$

DENSITY OF EQUIVALENT LIO. DRY AND AT 500. BARS P 420. PRED AB MOLE FRAC

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
DEN WET	2.350	2.342	2.333	2.324	2.316	2.307	2.299	2.290	2.281
DEN DRY	2.350	2.342	2.333	2.324	2.316	2.307	2.299	2.290	2.281

KUDO-WEILL GEOTHERMOMETER

XAB DRY	.892	.873	.833	.764	.657	.515	.357	.217	.118
XAB .5KB	.885	.857	.801	.709	.574	.410	.253	.136	.066
XAB 1.KB	.853	.818	.750	.642	.496	.334	.195	.101	.047
XAB 5.KB	.427	.342	.239	.144	.077	.037	.016	.007	.003

REVISED KUDO-WEILL GEOTHERMOMETER

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
XAB DRY	.953	.936	.902	.838	.728	.562	.171	.082	.036
XAB .5KB	.740	.714	.655	.563	.445	.141	.083	.045	.023
XAB 1.KB	.865	.853	.819	.759	.668	.545	.193	.114	.062

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	30.12	26.13	22.83	20.04	17.66	15.60	13.81	12.23	10.33
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LN VISC = 41610.35/T DEG K - 12.6416

DENSITY	SLOPE	INTERCEPT
WET	-.000086	2.4103
DRY	-.000086	2.4103

IDENTIFICATION FIELD READS...
PR-74-13 GLASS

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN- ERAL	MOLE PCNT	WEIGHT PCNT
SiO2	76.50	72.13	.00	82.87	83.24	83.24	O	33.02	35.02
TI02	.13	.09	.00	.11	.11	.11	C	.38	.34
ZR02	.00	.00	.00	.00			Z	.00	.00
AL2O3	12.40	13.78	.00	7.92	7.95	7.95	OR	29.47	28.96
CR2O3	.00	.00	.00	.00			PL	35.76	33.20
FE2O3	.33	.23	.00	.13	.14	.14	(AB)	34.00	31.48
FE0	.46	.36	.00	.42	.42	.42	(AN)	1.76	1.73
MNO	.05	.04		.05	.05	.05	LC	.00	.00
N10	.00	.00		.00			NE	.00	.00
MGO	.09	.13	.00	.15	.15	.15	KP	.00	.00
CA0	.54	.55	.00	.63	.63	.63	HL	.00	.00
SK0	.00	.00		.00	.00	.00	TH	.00	.00
BA0	.00	.00		.00			AC	.00	.00
NA2O	5.72	6.80	.00	3.91	3.92	3.92	NS	.00	.00
K2O	4.90	5.89	.00	3.39	3.40	3.40	KS	.00	.00
P2O5	.00	.00	.00	.00			WO	.00	.00
H2O+	.00			.00		.00	DI	.00	.00
H2O-	.00						(WO)	.00	.00
SO3	.00	.00	.00	.00			(EH)	.00	.00
S	.00		.00	4.14			(FS)	.00	.00
CL	.00		.00	.00			HY	.64	.67
F	.13		.00	.45			(EN)	.25	.22
CO2	.00	.00	.00	.00			(FS)	.39	.45
TOTAL	99.25						OL	.00	.00
-O=F,CL	99.20						(FO)	.00	.00
H2O	99.20						(FA)	.00	.00

TERNARY DIAGRAMS			WT PCT MOLPCT		CS	
		(NA+K)/AL	104.03	92.12	MT	.35 .48
		(FE+MN)/(FE+MN+MG)	92.03	83.43	CM	.00 .00
WT PCT MOLPCT		HA2O/(HA2O+K2O)	43.16	53.57	IL	.18 .25
		FE0/(FE0+FE2O3)	58.23	75.60	HM	.00 .00
Q	36.69	72.23	AN/PL	5.20 4.92	TN	.00 .00
AB	32.98	14.38	EN/HY	33.23 39.54	PF	.00 .00
OR	30.33	12.69	FA/OL	.00 .00	RU	.00 .00
		DIFNDX	95.45	96.49	AP	.00 .00
					FR	.19 .27
Q	64.90	82.15			PY	.00 .00
NE	17.86	9.56			CC	.00 .00
KP	17.24	8.29				

			PRED XLIZ TEMP	SALIC	98.63	97.52
			OLIVINE	975.	FEMIC	1.37 1.67
AN	2.78	2.70	CA-PYX	1074.		
AB	50.64	52.13	PLAG	1186.	TOTAL	100.00 99.19
OR	46.58	45.18				

CP = 21.250

A	90.74	91.28
F	0.32	0.90
M	.95	1.82

$$\text{MOLAR VOL (CAL/BAR)} = .63357 + (.25585-04)T \text{ DEG K}$$

DENSITY OF EQUIVALENT LIQ. DRY AND AT 500. BARS P H2O. PRED AB MOLE FRAC									
T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
DEN WET	2.350	2.342	2.333	2.324	2.316	2.307	2.298	2.290	2.281
DEN DRY	2.350	2.342	2.333	2.324	2.316	2.307	2.298	2.290	2.281

KUDO-WEILL GEOTHERMOMETER

XAB DRY	.898	.880	.842	.775	.671	.530	.371	.227	.124
XAB .5KB	.891	.864	.811	.721	.588	.424	.264	.143	.069
XAB 1.KB	.861	.827	.762	.656	.511	.348	.205	.106	.050
XAB 5.KB	.443	.357	.250	.152	.081	.039	.017	.007	.003

REVISED KUDO-WEILL GEOTHERMOMETER

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
XAB DRY	.956	.940	.908	.847	.739	.577	.179	.086	.038
XAB .5KB	.752	.727	.669	.578	.460	.148	.087	.048	.025
XAB 1.KB	.673	.660	.628	.770	.681	.560	.202	.120	.066

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	29.92	25.96	22.67	19.90	17.53	15.49	13.70	12.13	10.73
LN VISC =	41386.45/T DEG K -12.6080								

DENSITY	SLOPE	INTERCEPT
WET	-.000087	2.4111
DRY	-.000087	2.4111

IDENTIFICATION FIELD READS...
MR-74-16 GLASS

SPECIES	INPUT WT	CATION PCT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN-ERAL	MOLE PCT	WEIGHT PCT
SiO2	76.04	71.78	.00	82.43	83.14	83.14	O	33.25	35.22
Al2O3	.00	.04	.00	.05	.05	.05	C	1.65	1.49
ZrO2	.00	.00	.00	.00	.00	.00	Z	.00	.00
Al2O3	15.00	14.46	.00	8.30	8.38	8.38	OR	25.65	25.17
Cr2O3	.00	.00	.00	.00	.00	.00	PL	38.15	35.28
Fe2O3	.22	.16	.00	.09	.09	.09	(AB)	37.89	35.03
FeO	.36	.28	.00	.33	.33	.33	(AN)	.26	.25
MnO	.09	.07	.00	.08	.08	.08	LC	.00	.00
LiO	.00	.00	.00	.00	.00	.00	NE	.00	.00
MgO	.05	.07	.00	.08	.08	.08	KP	.00	.00
CaO	.42	.42	.00	.49	.49	.49	HL	.00	.00
SiO	.00	.00	.00	.00	.00	.00	TH	.00	.00
BAC	.00	.00	.00	.00	.00	.00	AC	.00	.00
Na2O	4.14	7.58	.00	4.35	4.39	4.39	NS	.00	.00
K2O	4.26	5.13	.00	2.95	2.97	2.97	KS	.00	.00
P2O5	.00	.00	.00	.00	.00	.00	WO	.00	.00
H2O+	.00	.00	.00	.00	.00	.00	DI	.00	.00
H2O-	.00	.00	.00	.00	.00	.00	(WO)	.00	.00
SO3	.00	.00	.00	.00	.00	.00	(EN)	.00	.00
S	.00	.00	.00	4.17	.00	.00	(FS)	.00	.00
CL	.00	.00	.00	.00	.00	.00	HY	.61	.67
F	.25	.00	.00	.86	.00	.00	(EN)	.14	.12
CO2	.00	.00	.00	.00	.00	.00	(FS)	.47	.55
TOTAL	98.89						OL	.00	.00
-O=F,CL	98.78						(FO)	.00	.00
H2O	98.78						(FA)	.00	.00

WT PCT	MOLPCT	WT PCT	MOLPCT	CS	MT	CM	IL	HM	IN	PF	RU	AP	FR	PY	CC
36.91	72.35	96.04	87.85	.00	.23	.00	.09	.00	.00	.00	.00	.00	.37	.00	.00
36.71	16.49	94.35	87.93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
26.38	11.16	49.29	59.63	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
		62.07	78.43	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
		.72	.68	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
		18.53	23.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
		95.42	96.78	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
				.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
				.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
				.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

PRED XLIZ TEMP	SALIC	98.70	97.16
OLIVINE	FEMIC	1.30	1.62
CA-PYX			
PLAG			
	TOTAL	100.00	98.78

CP = 21.250

93.02	93.02		
6.42	5.34		
.55	1.04		

MOLAR VOL (CAL/BAR) = .63430 + (.24821-04) T DEG K

DENSITY OF EQUIVALENT LIQ. DRY AND AT 500. BARS P H2O. PRED AB MOLE FRAC

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
DEN WET	2.349	2.340	2.332	2.323	2.315	2.307	2.298	2.290	2.281
DEN DRY	2.349	2.340	2.332	2.323	2.315	2.307	2.298	2.290	2.281

KUDO-WEILL GEOTHERMOMETER

XAB DRY	.930	.917	.888	.836	.750	.623	.462	.299	.170
XAB .5KB	.926	.906	.865	.793	.678	.519	.343	.195	.097
XAB 1.KB	.904	.878	.827	.739	.606	.438	.273	.147	.071
XAB 5.KB	.548	.455	.332	.210	.115	.056	.025	.011	.004

REVISED KUDO-WEILL GEOTHERMOMETER

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
XAB DRY	.970	.959	.936	.891	.807	.666	.474	.121	.054
XAB .5KB	.822	.801	.751	.670	.556	.203	.122	.068	.035
XAB 1.KB	.912	.903	.878	.832	.759	.651	.511	.165	.092

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	30.21	26.22	22.90	20.11	17.72	15.66	13.86	12.28	10.87
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LN VISC = 41717.94/T DEG K - 12.6577

DENSITY	SLOPE	INTERCEPT
WET	-.000084	2.4075
DRY	-.000084	2.4075

IDENTIFICATION FIELD READS...
MR 74-19 GLASS

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN- ERAL	MOLE PCNT	WEIGHT PCNT
SiO2	75.60	73.12	.00	83.42	84.05	84.05	O	39.23	39.48
TiO2	.07	.05	.00	.06	.06	.06	C	3.22	2.75
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.50	14.64	.00	8.35	8.41	8.41	OR	20.85	19.44
Cr2O3	.00	.00	.00	.00			PL	35.41	31.15
Fe2O3	.16	.12	.00	.07	.07	.07	(AB)	34.59	30.39
FeO	.37	.31	.00	.35	.35	.35	(AN)	.82	.76
MnO	.07	.06		.07	.07	.07	LC	.00	.00
HfO	.00	.00		.00			NE	.00	.00
MgO	.05	.04	.00	.05	.05	.05	KP	.00	.00
CaO	.39	.42	.00	.47	.48	.48	HL	.15	.15
SiO	.00	.00		.00	.00	.00	TH	.00	.00
BaO	.00	.00		.00			AC	.00	.00
Na2O	3.67	7.07	.00	4.03	4.06	4.06	NS	.00	.00
K2O	3.29	4.17	.00	2.38	2.40	2.40	KS	.00	.00
P2O5	.00	.00	.00	.00			WO	.00	.00
H2O+	.00			.00		.00	DI	.00	.00
H2O-	.00						(WO)	.00	.00
SO3	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.30			(FS)	.00	.00
CL	.09		.00	.17			HY	.60	.64
F	.16		.00	.57			(EN)	.09	.07
CO2	.00	.00	.00	.00			(FS)	.51	.56
TOTAL	94.40						OL	.00	.00
-O=F,CL	94.31						(FO)	.00	.00
H2O	94.31						(FA)	.00	.00

TERNARY DIAGRAMS			WT PCT MOLPCT			
		(NA+K)/AL	82.44	76.78	CS	.00 .00
		(FE+MN)/(FE+MN+MG)	96.17	91.62	MT	.18 .23
		NA2O/(NA2O+K2O)	52.73	62.90	CM	.00 .00
		FeO/(FeO+Fe2O3)	69.81	83.71	IL	.10 .13
Q	44.21	77.96	AN/PL	2.45 2.31	HM	.00 .00
AL	34.02	13.75	EN/HY	11.74 14.88	TN	.00 .00
OR	21.77	8.29	FA/OL	.00 .00	PF	.00 .00
			DIFNDX	89.32 94.67	RU	.00 .00
					AP	.00 .00
					FR	.25 .33
Q	69.20	84.71			PY	.00 .00
NE	18.43	9.54			CC	.00 .00
KP	12.37	5.75				
			PRED XLIZ TEMP		SALIC	98.87 92.98
			OLIVINE	1129.	FEMIC	1.13 1.33
			CA-PYX	1102.		
			PLAG	1176.		
AN	1.51	1.46			TOTAL	100.00 94.31
AB	60.06	61.49				
OR	38.43	37.06				

CP = 21.215

A	92.55	93.17
F	7.05	6.09
M	.40	.74

MOLAR VOL(CAL/BAR) = .63607 + (.22432-04)T DEG K

DENSITY OF EQUIVALENT LIQ. DRY AND AT 500. BARS P H2O. PRED AP MOLE FRAC

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
DEN WET	2.345	2.338	2.330	2.323	2.315	2.307	2.300	2.292	2.284
DEN DRY	2.345	2.338	2.330	2.323	2.315	2.307	2.300	2.292	2.284

KUDO-WEILL GEOTHERMOMETER

XAB DRY	.928	.914	.884	.831	.743	.614	.452	.291	.164
XAB .5KB	.923	.902	.861	.787	.669	.509	.334	.189	.094
XAB 1.KB	.901	.874	.821	.731	.597	.429	.265	.142	.068
XAB 5.KB	.539	.446	.324	.204	.111	.054	.024	.010	.004

REVISED KUDO-WEILL GEOTHERMOMETER

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
XAB DRY	.969	.958	.934	.887	.801	.657	.464	.116	.052
XAB .5KB	.817	.794	.744	.661	.546	.197	.118	.065	.034
XAB 1.KB	.909	.899	.873	.827	.752	.642	.501	.159	.089

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC 31.32 27.20 23.79 20.91 18.45 16.33 14.47 12.84 11.39

LN VISC = 42981.26/T DEG K - 12.8472

DENSITY	SLOPE	INTERCEPT
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WET	-.000076	2.3989
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DRY	-.000076	2.3989
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IDENTIFICATION FIELD READS...
MR 74-22 GLASS

SPECIES	INPUT WT PCT	CATION PCT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN- ERAL	MOLE PCT	WEIGHT PCT
S102	75.96	71.25	.00	82.03	82.83	82.83	O	31.93	34.01
T102	.06	.04	.00	.05	.05	.05	C	1.63	1.47
ZR02	.00	.00	.00	.00			Z	.00	.00
AL203	15.38	14.72	.00	8.47	8.55	8.55	OR	28.92	28.54
CR203	.00	.00	.00	.00			PL	36.32	33.78
FE203	.20	.14	.00	.08	.08	.08	(AB)	36.11	33.57
FE0	.30	.24	.00	.27	.27	.27	(AN)	.21	.20
MNO	.09	.07		.08	.08	.08	LC	.00	.00
NIO	.00	.00		.00			NE	.00	.00
NGO	.02	.03	.00	.03	.03	.03	KP	.00	.00
CA0	.41	.41	.00	.47	.48	.48	HL	.10	.10
SK0	.00	.00		.00	.00	.00	TH	.00	.00
BA0	.00	.00		.00			AC	.00	.00
NA20	4.02	7.32	.00	4.21	4.25	4.25	NS	.00	.00
K20	4.85	5.78	.00	3.33	3.36	3.36	KS	.00	.00
P205	.00	.00	.00	.00			WO	.00	.00
H20+	.00			.00		.00	DI	.00	.00
H20-	.00						(WO)	.00	.00
S03	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.15			(FS)	.00	.00
CL	.06		.00	.11			HY	.44	.50
F	.25		.00	.85			(EN)	.06	.05
CO2	.00	.00	.00	.00			(FS)	.39	.45
TOTAL	99.44						OL	.00	.00
-O=F,CL	99.32						(FO)	.00	.00
H20	99.32						(FA)	.00	.00

TERNARY DIAGRAMS			WT PCT MOLPCT			
			(NA+K)/AL	99.33	89.03	MT
			(FE+MN)/(FE+MN+MG)	97.35	94.13	CM
			WT PCT MOLPCT	NA20/(NA20+K20)	45.42 55.85	IL
				FE0/(FE0+FE203)	60.00 76.93	HM
Q	35.38	71.05		AN/PL	.60 .57	TI
AB	34.93	16.07		EN/HY	9.89 12.60	PF
OR	29.69	12.87		FA/OL	.00 .00	RU
			DIFNDX	96.12 96.96		AP
						FR
Q	64.21	81.67				TY
NE	18.92	10.18				CC
KP	16.87	8.15				

			PRED XLIZ TEMP	SALIC	98.89	97.00
			OLIVINE	FEMIC	1.11	1.42
AN	.33	.32	CA-PYX			
AB	53.87	55.35	PLAG	TOTAL	100.00	99.32
OR	45.80	44.33				

CP = 21.275

A	94.45	95.15				
F	5.34	4.45	MOLAR VOL(CAL/BAR) = .63564 + (.25843-04)T DEG K			
M	.21	.41				

DENSITY OF EQUIVALENT LIQ. DRY AND AT 500. BARS P H2O. PRED AB MOLE FRAC

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
DEN WLT	2.349	2.341	2.332	2.323	2.314	2.306	2.297	2.288	2.280
DEN DRY	2.349	2.341	2.332	2.323	2.314	2.306	2.297	2.288	2.280

KUDO-WEILL GEOTHERMOMETER

XAB DRY	.934	.921	.893	.841	.757	.630	.469	.304	.173
XAB .5KB	.930	.910	.870	.800	.686	.526	.349	.199	.099
XAB 1.KB	.909	.884	.833	.746	.614	.446	.278	.150	.072
XAB 5.KB	.565	.468	.343	.217	.119	.058	.026	.011	.004

REVISED KUDO-WEILL GEOTHERMOMETER

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
XAB DRY	.972	.961	.939	.895	.812	.673	.480	.123	.055
XAB .5KB	.831	.809	.760	.679	.565	.208	.125	.069	.036
XAB 1.KB	.917	.907	.883	.838	.765	.658	.517	.168	.094

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	30.03	26.05	22.75	19.98	17.60	15.55	13.76	12.18	10.78
LN VISC =	41507.74/T DEG K -12.6262								

DENSITY	SLOPE	INTERCEPT
WET	-.000087	2.4103
DRY	-.000087	2.4103

IDENTIFICATION FIELD READS...
MR 75-14

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN-ERAL	MOLE PCNT	WEI HT PCNT
SiO2	76.42	71.25	.00	81.42	82.75	82.36	Q	30.04	32.22
TiO2	.04	.03	.00	.03	.03	.03	C	.45	.41
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.79	14.05	.00	8.03	8.16	8.12	OR	28.07	27.89
Cr2O3	.00	.00	.00	.00			PL	39.95	37.40
Fe2O3	.20	.14	.00	.08	.08	.08	(AB)	39.95	37.40
FeO	.38	.30	.00	.34	.34	.34	(AN)	.00	.00
MnO	.05	.04		.05	.05	.05	LC	.00	.00
NiO	.00	.00		.00			NE	.00	.00
MgO	.11	.15	.00	.17	.18	.18	KP	.00	.00
CaO	.44	.44	.00	.50	.51	.51	HL	.00	.00
SrO	.00	.00		.00	.00	.00	TH	.00	.00
BaO	.00	.00		.00			AC	.00	.00
Na2O	4.42	7.99	.00	4.57	4.64	4.62	NS	.00	.00
K2O	4.72	5.61	.00	3.21	3.26	3.24	KS	.00	.00
P2O5	.00	.00	.00	.00			WO	.00	.00
H2O+	.13			.46		.47	DI	.00	.00
H2O-	.01						(WO)	.00	.00
SO3	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.09			(FS)	.00	.00
CL	.00		.00	.00			HY	.78	.83
F	.34		.12	1.15			(EN)	.31	.27
CO2	.00	.00	.00	.00			(FS)	.48	.56
TOTAL	100.05						OL	.00	.00
-O=F,CL	99.91						(FO)	.00	.00
H2O	99.77						(FA)	.00	.00

TERTIARY DIAGRAMS			WT PCT	MOLPCT		
			(NA+K)/AL	106.32	96.79	CS
			(FE+MN)/(FE+MN+MG)	87.72	75.70	MT
			Na2O/(Na2O+K2O)	48.36	58.73	CM
			FeO/(FeO+Fe2O3)	65.52	80.95	IL
			AN/PL	.00	.00	HM
			EN/HY	32.87	39.15	TN
			FA/OL	.00	.00	PF
			DIFIDX	97.52	98.06	RU
						AP
						FR
						PY
						CC
Q	33.04	68.83				
AB	38.35	18.31				
OR	28.60	12.66				
Q	62.97	80.80				
NE	20.78	11.28				
KP	16.25	7.92				
AN	.00	.00				
AB	57.28	58.73				
OR	42.72	41.27				

CP = 21.256

A	92.98	92.91
F	5.90	5.01
M	1.12	2.09

MOLAR VOL(CAL/BAR) = .63309 + (.26155-04)T DEG K

SALIC	98.51	97.93
FEMIC	1.49	1.81
TOTAL	100.00	99.74

DENSITY OF EQUIVALENT LIO. DRY AND AT 500. BARS P H2O. PRED AB MOLE FRAC									
T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
DLN WET	2.347	2.339	2.330	2.322	2.313	2.304	2.296	2.287	2.278
DEN DRY	2.347	2.339	2.330	2.322	2.313	2.304	2.296	2.287	2.278

KUDO-WEILL GEOTHERMOMETER

XAB DRY	.932	.919	.892	.843	.761	.638	.480	.315	.181
XAB .5KB	.927	.908	.870	.801	.690	.535	.359	.207	.105
XAB 1.KB	.906	.881	.833	.748	.620	.455	.287	.157	.076
XAB 5.KB	.552	.463	.342	.219	.121	.060	.027	.011	.005

REVISED KUDO-WEILL GEOTHERMOMETER

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
XAB DRY	.971	.961	.939	.896	.816	.680	.491	.129	.058
XAB .5KB	.825	.805	.759	.681	.570	.219	.130	.073	.038
XAB 1.KB	.914	.905	.882	.839	.769	.665	.528	.176	.099

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	29.98	26.01	22.72	19.95	17.57	15.52	13.74	12.16	10.76
LN VISC = 41459.96/T DEG K	-12.6190								

DENSITY	SLOPE	INTERCEPT
WLT	-.000086	2.4078
DRY	-.000086	2.4078

IDENTIFICATION FIELD READS...
MR 75-18 GLASS

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN-ERAL	MOLE PCNT	WEIGHT PCNT
SiO2	75.80	71.66	.00	82.05	83.11	83.11	Q	31.99	33.84
TiO2	.08	.06	.00	.07	.07	.07	C	1.01	.91
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.70	14.15	.00	8.10	8.21	8.21	OR	27.56	27.01
Cr2O3	.00	.00	.00	.00			PL	38.13	35.20
Fe2O3	.22	.16	.00	.09	.09	.09	(AB)	38.13	35.20
FeO	.33	.26	.00	.30	.30	.30	(AN)	.00	.00
MnO	.11	.09		.10	.10	.10	LC	.00	.00
NiO	.00	.00		.00			NE	.00	.00
MgO	.05	.04	.00	.05	.05	.05	KP	.00	.00
CaO	.32	.32	.00	.37	.38	.38	HL	.13	.13
SrO	.00	.00		.00	.00	.00	TH	.00	.00
LaO	.00	.00		.00			AC	.00	.00
Na2O	4.25	7.75	.00	4.44	4.50	4.50	NS	.00	.00
K2O	4.57	5.51	.00	3.16	3.20	3.20	KS	.00	.00
P2O5	.00	.00	.00	.00			WO	.00	.00
H2O+	.00			.00		.00	DI	.00	.00
H2O-	.00						(WO)	.00	.00
SO3	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.14			(FS)	.00	.00
CL	.08		.00	.15			HY	.51	.57
F	.33		.34	1.13			(EN)	.08	.07
CO2	.00	.00	.00	.00			(FS)	.43	.50
TOTAL	98.80						OL	.00	.00
-O=F,CL	98.64						(FO)	.00	.00
H2O	98.64						(FA)	.00	.00

TERNARY DIAGRAMS			WT PCT MOLPCT				
			(Na+K)/Al	103.13	93.74	MT	.23 .32
			(Fe+Mn)/(Fe+Mn+Mg)	96.48	92.28	CM	.00 .00
			Na2O/(Na2O+K2O)	48.07	58.45	IL	.11 .15
			FeO/(FeO+Fe2O3)	60.00	76.93	HM	.00 .00
Q	35.23	70.89	AN/PL	.00	.00	TN	.00 .00
AB	36.65	16.90	EN/HY	13.08	16.51	PF	.00 .00
OR	28.12	12.21	FA/OL	.00	.00	RU	.00 .00
			DIFNDX	96.04	97.67	AP	.00 .00
						FR	.32 .45
Q	64.17	81.60				PY	.00 .00
NE	19.85	10.68				CC	.00 .00
KP	15.98	7.72					

			PRED XLIZ TEMP		SALIC	98.82	97.09
			OLIVINE	1010.	FEMIC	1.18	1.49
AN	.00	.00	CA-PYX	1079.			
AB	56.59	58.05	PLAG	1179.	TOTAL	100.00	98.57
OR	43.41	41.95					

CP = 21.246

A	93.32	94.56	MOLAR VOL(CAL/BAR) = .63454 + (.25605-04)T DEG K
F	5.36	4.84	
M	.32	.60	

DENSITY OF EQUIVALENT LIQ. DRY AND AT 500. BARS P H2O. PRED AB MOLE FRAC									
T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
DEN WET	2.348	2.339	2.330	2.322	2.313	2.304	2.296	2.287	2.278
DEN DRY	2.348	2.339	2.330	2.322	2.313	2.304	2.296	2.287	2.278

KUDO-WEILL GEOTHERMOMETER

XAB DRY	.943	.933	.909	.866	.793	.679	.525	.355	.209
XAB .5KB	.939	.923	.890	.829	.728	.580	.402	.238	.123
XAB 1.KB	.921	.900	.857	.782	.662	.500	.325	.182	.090
XAB 5.KB	.600	.510	.385	.252	.142	.071	.032	.014	.005

REVISED KUDO-WEILL GEOTHERMOMETER

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
XAB DRY	.976	.967	.949	.912	.842	.718	.536	.150	.069
XAB .5KB	.851	.834	.791	.720	.615	.480	.152	.085	.045
XAB 1.KB	.928	.921	.900	.863	.800	.705	.573	.203	.116

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	29.97	26.00	22.71	19.93	17.56	15.52	13.73	12.15	10.76
LN VISC = 41442.59/T DEG K - 12.6164									

DENSITY	SLOPE	INTERCEPT
WET	-.000086	2.4081
DRY	-.000086	2.4081

IDENTIFICATION FIELD READS...

MR-75-20 GLASS

SPECIES	INPUT WT	CATION PCT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN-ERAL	MOLE PCNT	WEIGHT PCNT
S102	76.50	71.58	.00	82.11	83.04	83.04	Q	31.61	33.78
Ti02	.07	.05	.00	.06	.06	.06	C	.87	.79
ZR02	.00	.00	.00	.00			Z	.00	.00
AL203	12.80	14.12	.00	8.10	8.19	8.19	OR	27.34	27.06
CR203	.00	.00	.00	.00			PL	38.92	36.30
FE203	.31	.22	.00	.13	.13	.13	(AB)	38.92	36.30
FE0	.30	.23	.00	.27	.27	.27	(AN)	.00	.00
MNO	.11	.09		.10	.10	.10	LC	.00	.00
HI0	.00	.00		.00			NE	.00	.00
HGO	.04	.06	.00	.06	.06	.06	KP	.00	.00
CA0	.40	.40	.00	.46	.47	.47	HL	.00	.00
SR0	.00	.00		.00	.00	.00	TH	.00	.00
BA0	.00	.00		.00			AC	.00	.00
HA20	4.29	7.78	.00	4.46	4.51	4.51	NS	.00	.00
K20	4.58	5.47	.00	3.14	3.17	3.17	KS	.00	.00
P205	.00	.00	.00	.00			WO	.00	.00
H20+	.00			.00		.00	DI	.00	.00
H20-	.00						(WO)	.00	.00
S03	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.13			(FS)	.00	.00
CL	.00		.00	.00			HY	.44	.48
F	.33		.17	1.12			(EN)	.11	.10
CO2	.00	.00	.00	.00			(FS)	.33	.38
TOTAL	99.73						OL	.00	.00
-O=F,CL	99.59						(FO)	.00	.00
H20	99.59						(FA)	.00	.00

TERNARY DIAGRAMS			WT PCT MOLPCT			
			(NA+K)/AL	103.10	93.86	CS
			(FE+MN)/(FE+MN+MG)	95.69	90.64	MT
			HA20/(HA20+K20)	48.37	58.74	CM
			FE0/(FE0+FE203)	49.18	68.26	IL
Q	34.77	70.46	AN/PL	.00	.00	HM
AB	37.37	17.35	EN/HY	20.61	25.44	TN
OR	27.86	12.19	FA/OL	.00	.00	PF
			DIFNDX	97.15	97.87	RU
						AP
						FR
Q	63.93	81.43				PY
NE	20.24	10.91				CC
KP	15.83	7.66				

			PRED XLIZ TEMP		SALIC	98.73	97.93
			OLIVINE	986.	FEMIC	1.27	1.62
AN	.00	.00	CA-PYX	1079.			
AB	57.29	58.74	PLAG	1183.	TOTAL	100.00	99.55
OR	42.71	41.26					

CP = 21.253

A	93.17	94.31		
F	6.41	4.90	MOLAR VOL(CAL/BAR) =	.63444 + (.25604-04)T DEG K
M	.42	.79		

DENSITY OF EQUIVALENT LIQ. DRY AND AT	500.	BARS P	H2O.	PRED AB	MOLE FRAC				
T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
DEN WET	2.348	2.340	2.331	2.322	2.314	2.305	2.296	2.288	2.279
DEN DRY	2.348	2.340	2.331	2.322	2.314	2.305	2.296	2.288	2.279

KUDO-WEILL GEOTHERMOMETER

XAB DRY	.932	.919	.891	.841	.758	.634	.475	.311	.178
XAB .5KB	.927	.908	.869	.799	.687	.531	.355	.203	.103
XAB 1.KB	.906	.881	.831	.746	.616	.450	.283	.154	.075
XAB 5.KB	.552	.461	.340	.216	.120	.059	.026	.011	.004

REVISED KUDO-WEILL GEOTHERMOMETER

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
XAB DRY	.971	.960	.938	.895	.813	.676	.486	.126	.057
XAB .5KB	.825	.805	.757	.678	.567	.212	.128	.071	.037
XAB 1.KB	.914	.905	.881	.837	.767	.661	.523	.172	.097

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	29.87	25.91	22.63	19.86	17.50	15.46	13.67	12.10	10.71
LN VISC =	41332.49/T DEG K -12.5999								

DENSITY	SLOPE	INTERCEPT
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WET	-.000087	2.4087
DRY	-.000087	2.4087

IDENTIFICATION FIELD READS...

MR-75-30 GLASS

SPECIES	INPUT WT PCT	CATION PCNT	COMP ERROR	INPUT MOLPCT	DRY OX MOLPCT	WET OX MOLPCT	MIN- ERAL	MOLE PCNT	WEIGHT PCNT
SiO2	74.80	71.29	.00	82.27	82.36	82.36	O	32.24	33.83
AlO2	.14	.10	.00	.12	.12	.12	C	.24	.21
ZrO2	.00	.00	.00	.00			Z	.00	.00
Al2O3	12.90	14.49	.00	8.36	8.37	8.37	OR	30.76	29.90
Cr2O3	.00	.00	.00	.00			PL	35.31	32.62
Fe2O3	.30	.22	.00	.12	.12	.12	(AB)	30.12	27.59
FeO	.55	.44	.00	.51	.51	.51	(AN)	5.19	5.04
MnO	.05	.04		.05	.05	.05	LC	.00	.00
NiO	.00	.00		.00			NE	.00	.00
NaO	.12	.17	.00	.20	.20	.20	KP	.00	.00
CaO	1.06	1.03	.00	1.25	1.25	1.25	HL	.00	.00
SR0	.00	.00		.00	.00	.00	TH	.00	.00
BaO	.00	.00		.00			AC	.00	.00
Na2O	3.26	6.02	.00	3.48	3.48	3.48	NS	.00	.00
K2O	5.06	6.15	.00	3.55	3.55	3.55	KS	.00	.00
P2O5	.00	.00	.00	.00			WO	.00	.00
H2O+	.00			.00		.00	DI	.00	.00
H2O-	.00						(WO)	.00	.00
SO3	.00	.00	.00	.00			(EN)	.00	.00
S	.00		.00	4.11			(FS)	.00	.00
CL	.00		.00	.00			HY	.88	.92
F	.03		.00	.10			(EN)	.34	.30
CO2	.00	.00	.00	.00			(FS)	.54	.62
TOTAL	98.27						OL	.00	.00
-O=F,CL	98.26						(FO)	.00	.00
H2O	98.26						(FA)	.00	.00

TERNARY DIAGRAMS			WT PCT MOLPCT			
			(NA+K)/AL	96.95	84.03	CS
			(FE+MN)/(FE+MN+MO)	90.33	80.28	MT
			Na2O/(Na2O+K2O)	39.18	49.48	CM
			FeO/(FeO+Fe2O3)	64.71	80.30	IL
Q	37.05	72.59	AN/PL	15.45	14.69	HM
AB	30.21	13.56	EN/HY	32.39	38.63	TN
OR	32.74	13.85	FA/OL	.00	.00	PF
			DIFNDX	91.32	93.12	RU
						AP
						FR
						PY
						CC
Q	65.03	82.29				
NE	16.36	8.76				
KP	18.61	8.95				
			PRED XLIZ TEMP			SALIC 98.55 96.57
			OLIVINE	991.		FEMIC 1.45 1.69
			CA-PYX	1076.		
			PLAG	1194.		TOTAL 100.00 98.25
AN	8.06	7.85				
AB	44.12	45.59				
OR	47.82	46.56				

$$CP = 21.317$$

A	89.56	89.47	MOLAR VOL(CAL/DAR) = .63250 + (.25929-04)T DEG K
F	9.15	8.02	
M	1.29	2.51	

DENSITY OF EQUIVALENT LIQ. DRY AND AT 500. BARS P H2O. PRED AB MOLF FRAC									
T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
DEN WET	2.360	2.351	2.342	2.333	2.325	2.316	2.307	2.298	2.289
DEN DRY	2.360	2.351	2.342	2.333	2.325	2.316	2.307	2.298	2.289

KUDO-WEILL GEOTHERMOMETER

XAB DRY	.842	.812	.752	.657	.527	.377	.237	.133	.068
XAB .5KB	.833	.789	.710	.591	.438	.283	.159	.080	.037
XAB 1.KB	.791	.738	.646	.516	.363	.222	.120	.058	.026
XAB 5.KB	.326	.246	.160	.091	.046	.021	.009	.004	.002

REVISED KUDO-WEILL GEOTHERMOMETER

T DEG C	700.	800.	900.	1000.	1100.	1200.	1300.	1400.	1500.
XAB DRY	.929	.902	.849	.755	.608	.205	.103	.047	.020
XAB .5KB	.649	.610	.536	.215	.141	.085	.048	.025	.013
XAB 1.KB	.807	.784	.733	.651	.533	.194	.118	.066	.035

NATURAL LOGARITHM OF VISCOSITY OF LIQUID, AFTER SHAW (1972)

LN VISC	29.67	25.74	22.47	19.72	17.37	15.34	13.56	12.00	10.62
LN VISC = 41107.30/T DEG K - 12.5661									

DENSITY	SLOPE	INTERCEPT
WET	-.000088	2.4215
DRY	-.000088	2.4215