Gosefnanefnd
iðnaðarráðuneytisins

EFNASAMSETNING Á PERLUSTEINI Í PRESTAHNÚK

eftir

Gylfa Einarsson

og

Stefán Arnórsson

OSJKD7301

Apríl 1973

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Efnisyfirlit

0. Inngangur.

Efnagreiningarnar í meðfylgjandi skýrslu voru unnar af Gylfa Einarssyni á Jarðfræðistofu Raunvísindastofnunar háskólans undur umsjón Stefáns Arnórssonar og eftir beiðni gosefnanefndar iðnaðarráðuneytisins.

Alls voru 22 sýni efnagreind og voru þau valin af Aðalsteini Jónssyni, Stefáni Arnórssyni og Gylfa Einarssyni úr þeim hópi sýna, sem tekinn var meðan á rannsóknum John-Manville og Perlitnefndar stóð í Prestahnúki sumarið 1971, en þessi sýni hafa verið á geymslu á Rannsóknarstofnun iðnaðarins. Sýnin voru valin með það fyrir augum að víðtækar þensluprófanir yrðu gerðar á þeim auk efnagreininganna.

Tilgangur efnagreininganna var þríþættur:

(1) Að gera sér sem bezta grein fyrir samsetningu perlusteinsins með samanburði við perlustein, sem er unninn í öðrum löndum.

(2) Að fá upplýsingar um hversu jöfn (hómógen) efnasamsetningin er í hnúknum.

(3) Að sjá hver áhrif efnasamsetning hefur á þenslueiginleika og notfæra sér niðurstöður hennar fyrir túlkun á prófunum á forþurrkun og þenslu.

Þessa skýrslu ber að skoða sem framvinduskýrslu, þar sem aðaltilgangurinn er að birta niðurstöður efnagreininga. Mælt er með því að gera lokaskýrslu, þar sem áherzla verður lögð á samanburð efnasamsetningar við þenslueiginleika og útlit perlusteins í þunnsneið.

Númering á sýnum er sú sama og í skýrslu gosefnanefndar: Perlusteinsrannsóknir á Íslandi stutt yfirlit, des. 1972.

1. Efnagreiningaraðferðir

SiO_2, Al_2O_3, TiO_2 og Fe total sem Fe_2O_3 var ákvarðað með röntgenfluorence.

FeO var ákvarðað með $K_2Cr_2O_7$ títrun.

MgO og CaO var ákvarðað með atomic absorption.

Na_2O og K_2O var ákvarðað með logafotometer.

MnO og P_2O_5 var ákvarðað spektoifotometískt.

H_2O^+ var ákvarðað gravimetríska eftir glæðingu.

H_2O^- var ákvarðað gravimetríska eftir þurrkun í 7 klst. við 105°C.

2. Niðurstöður

2.1. Skekkjuvaldar

Allmargar af efnagreiningunum hafa of lága summu. Fjórtán liggja ofan við 99 %, sex milli 99 og 98 % og þrjár fyrir neðan 98 %. Þess er helzt að vænta að skekkjan liggi í SiO_2 - ákvörðun, en ekki var aðstaða til að endurtaka mælingar á SiO_2 að sinni. Meðaltal af summum þeirra efnagreininga, sem liggja ofan við 99 % er 99,36 %. Meðaltal af SiO_2 - ákvörðunum er 74,02 %. Meðaltal af summum þeirra efnagreininga, sem liggja neðan við 99 % er hins vegar 98,26 % og meðaltal SiO_2 - ákvarðana 73,22 %. Bendir þetta til að skekkja í SiO_2 - ákvörðun eigi stóran þátt í þessari lágu útkomu. Þess ber einnig að gæta, að snefilefni geta verið allt að 0.5 %. Eru þau helztu Ba, Cl, La, Rb, Sr og Zr.

2.2 Efnasamsetning perlusteins.

Tafla 1. Meðalefnasamsetning perlusteins í Prestahnúki og skekkjur í efnagreiningu

	Meðal % Frávik	Samkvæmni með 95% vissu í %	Meðaltal Efnagr.	Lágmark marktæks mismunar	spönn einstakra efna
SiO_2	0.46	1.43	73.73	1.05	72.05 - 75.95
Al_2O_3	1.09	3.19	12.22	0.39	11.76 - 13.03
TiO_2	1.54	4.34	0.13	0.06	0.10 - 0.23
Fe_2O_3			0.77		0.60 - 1.02
FeO	2.22	4.88	0.81	0.04	0.50 - 1.02
MgO	6.69	15.57	0.04	0.01	0.02 - 0.14
CaO	1.17	2.68	0.30	0.01	0.20 - 0.41
Na_2O	5.28	15.03	3.94	0.59	3.26 - 4.36
K_2O	1.25	4.10	3.29	0.14	3.09 - 3.60
MnO	16.05	38.16	0.01	0.04	0.00 - 0.04
P_2O_5	1.12	4.38	0.02	0.001	0.02 - 0.04
H_2O_{tot}	9.70	31.38	3.73	1.15	1.60 - 5.39
Fe_2O_3tot	1.56	4.16	1.66	0.07	1.43 - 1.84

Að H_2O total undanteknu eru tölurnar í tveim fremstu dálkunum fengnar úr skýrslu Einars Gunnlaugssonar og Gests Gíslasonar: "Efnagreiningar á íslenzku basalti vegna hugsanlegrar basaltbræðslu". Þessar tölur eru fengnar við endurteknar greiningar á basalti og eru því ekki algerlega yfirfæranlegar á perlusteini vegna annarrar efnasamsetningar. Útreiknaðar skekkjur fyrir H_2O total eru fengnar frá endurteknum mælingum á perlusteini.

Í töflu 2 sézt, að lítill breytileiki er í samsetningu perlusteinsins, þó talsvert meiri en nemur marktækum mun og því ekki unnt að segja, að perlusteinninn sé hómógen fyrir öll aðalefni. Heildarefnasamsetningin er æskileg fyrir þenjanlegan perlustein. Líklega mun breytileiki flestra efnanna ekki skipta máli fyrir þenslueiginleika perlusteinsins. Undantekningar eru þó Na_2O, K_2O og sér í lagi H_2O, en styrkur hins síðastnefnda er mjög breytilegur og ætti sá breytileiki að geta haft áhrif á þenslu svo og hvers konar forhitun er nauðsynleg.

3. Tillögur um frekari efnarannsóknir

Mælt er með því, að frekari efnarannsóknir feli í sér ákvörðun á H_2O og Na_2O og K_2O og verði síðan reynt að samræma niðurstöður efnagreininganna við þenslueiginleika, útlit í þunnsneið og handstykki. Þessi samanburður ætti að leiða til aukins skilnings á mismunandi þenslueiginleikum einstakra sýna og skapa reynslu til að dæma um þenslueiginleikana eftir útliti handstykkja. Að auki er talið að þessi samanburður veiti vitneskju um það, hvernig perlusteinn myndast, en vatnsinnihald hans er óvenju hátt miðað við annað súrt gosberg.

THE CHEMICAL COMPOSITION OF PERLITE FROM PRESTAHNÚKUR

by

Gylfi Einarsson

and

Stefán Arnórsson

apríl 1973

Contents

0. Introduction

The chemical analyses in this report were carried out by Gylfi Einarsson at the Geology Division of the Science Institution under the supervision of Stefán Arnórsson and at the request of the Committee of Volcanic Materials.

Altogether 22 samples were analysed and they were selected by Adalsteinn Jónsson, Stefán Arnórsson, and Gylfi Einarsson from the collection of samples taken during the investigations of Johns Manville and the Perlite Committee in Prestahnúkur during the summer of 1971, but these samples have been stored at the Industrial Research Institute. The samples were selected on the assumption that extensive expansion tests would be carried out on them in addition to the chemical analyses.

The purpose of the analyses was threefold:

(1) to reveal as well as possible the composition of the perlite and compare it with the composition of exploited perlite in other countries.

(2) to obtain information on the homogenuity of the perlite in the Prestahnúkur formation.

(3) to observe the relation between composition and expansion properties of the perlite and apply the results for interpreting expansion tests and pre-heating treatment.

This report is a preliminary one and its main purpose is to make available the results of the chemical analyses. It is proposed to write a final report where comparison between composition expansion properties, and microscopic character of the perlite will be emphasized.

The sample numbers are those of the report by the Committee on Volcanic Materials: Studies of Perlite in Iceland - a brief review, Dec. 1972.

1. Analytical Techniques

SiO_2, Al_2O_3, TiO_2 and Fe total were determined by X-ray fluorescence.

FeO was determined by HF-H_2SO_4 solution and $K_2Cr_2O_7$ titration.

MgO and CaO were determined by atomic absorption .

Na_2O and K_2O were determined by flame photometry.

MnO was determined colorimetrically after oxidation to permanganate.

P_2O_5 was determined colorimetrically by estimation of the molybdate - vanadate complex.

H_2O^+ was determined gravimetrically after fusion.

H_2O^- was determined by drying at 105°C for 7 hours.

2. Results

2.1 Sources of error

Several of the analyses have a low sum; 14 have a sum above 99%, 6 between 99 and 98% and 3 below 98%. It is expected that the low sum lies in the SiO_2 determination but for the time being it was not possible to repeat the measurements. The average of the sums of those analyses which are above 99% is 99.36% and the average SiO_2 content 74.02%. The average of the sums which are below 99% is on the other hand 98.26% and here the average silica content is 73.22%. This supports the suggestion that the low sum is mostly due to low SiO_2 values. It should also be pointed out that trace elements can amount to as much as 0.5%. The most important trace elements are Ba, Cl, La, Cb, Sr and Zr.

2.2 The composition of the perlite

From table 1 it can be seen that there is little variation in the composition of the perlite. Yet it is considerably higher than analytical error and therefore it cannot be stated that the perlite is homogeneous with respect to all of the major components. The overall composition is desirable for perlite. Probably the variation in the concentration of most of the components will not be significant for expansion properties. Na_2O, K_2O and in particular H_2O are, however, exceptions, but the H_2O concentrations are very variable and this variability might well influence expansion and the kind of preheating required.

Table 1. The average composition of perlite in Prestahnúkur and analytical errors.

Compound	Mean% deviation	Precision at the 95% c.l.	average compos.	lower limit of sign.diff.	Conc. range
SiO_2	0.46	1.43	73.73	1.05	72.05-75.95
Al_2O_3	1.09	3.19	12.22	0.39	11.76-13.03
TiO_2	1.54	4.34	0.13	0.06	0.10-0.23
Fe_2O_3			0.77		0.60-1.02
FeO	2.22	4.88	0.81	0.04	0.50-1.02
MgO	6.69	15.57	0.04	0.01	0.02-0.14
CaO	1.17	2.68	0.30	0.01	0.20-0.41
Na_2O	5.28	15.03	3.94	0.59	3.26-4.36
K_2O	1.25	4.10	3.29	0.14	3.08-3.60
MnO	16.05	38.16	0.01	0.04	0.00-0.04
P_2O_5	1.12	4.38	0.02	0.001	0.02-0.04
H_2Otot.	9.70	31.38	3.73	1.15	1.60-5.39
Fe_2O_3tot.	1.56	4.16	1.66	0.07	1.43-1.84

With the exception of H_2O total the figures in the 2 first columns have been obtained from a report on basalt casting by Einar Gunnlaugsson and Gestur Gíslason. These figures were derived from duplicate analyses of basalt and are not directly applicable for perlite because of difference in composition. The calculated error for H_2O total were obtained by duplicate analyses of perlite.

3. Proposals for further chemical studies

It is recommended that further chemical studies involve analyses of H_2O, Na_2O and K_2O and correlation between chemical composition, expansion properties, microscopic characteristics and hand specimen be attempted. This correlation should improve understanding regarding variable expansion properties of individual samples and should create experience to judge expansion properties according to the outlook of hand specimens. In addition, it is believed, that this correlation increase knowledge about how perlite may form, but its water content is unusually high compared with other acid volcanic glasses.

B-3, 23-25.2

SIO2	73.35	73.44
AL2O	12.28	7.24
TIO2	.14	.10
FE2O	.81	.30
FEO	.93	.77
MNO	.03	.02
MGO	.02	.02
CAO	.38	.40
NA2O	4.36	4.23
K2O	3.42	2.18
P2O5	.03	.01
H2O	3.36	11.23
	99.11	100.00

H_2O^+ : 3.25

H_2O^- : 0.11

QZ	33.68
OR	20.21
AB	36.89
AN	1.70
LC	0.00
NE	0.00
CO	0.00
WO	0.00
EN	0.00
FS	0.00
EN	.04
FS	.86
FO	0.00
FA	0.00
MT	1.17
IM	.26
HM	0.00
AP	.06
RT	0.00
VN	3.35
	98.28

A	82.2
F	17.5
M	.2

DI	0.0
QZ	97.3
HY	2.6

FE2O3/FEO .87096

OR	34.3
AB	62.7
AN	2.9

QZ	37.1
OR	22.2
AB	40.6

: :

C-2 10.5-14.4

SIO2	73.80	73.30
AL2O	12.14	7.10
TIO2	.10	.07
FE2O	.99	.37
FEO	.72	.59
MNO	0.00	0.00
MGO	.04	.05
CAO	.32	.34
NA2O	3.82	3.67
K2O	3.60	2.28
P2O5	.03	.01
H2O	3.67	12.16
	99.23	100.00

H_2O^+ : 3.46

H_2O^- : 0.21

QZ	36.92
OR	21.27
AB	32.32
AN	1.41
LC	0.00
NE	0.00
CO	.01
WO	0.00
EN	0.00
FS	0.00
EN	.09
FS	.33
FO	0.00
FA	0.00
MT	1.43
IM	.18
HM	0.00
AP	.06
RT	0.00
VN	3.66
	97.74

A	81.7	DI	0.0
F	17.7	QZ	98.8
M	.4	HY	1.1

FE2O3/FEO 1.37500

OR	38.6	QZ	40.7
AB	58.7	OR	23.5
AN	2.5	AB	35.7

C-3 11-15

SIO2	73.45	69.51
AL2O	11.95	6.66
TIO2	.10	.07
FE2O	.67	.23
FEO	.87	.68
MNO	0.00	0.00
MGO	.04	.05
CAO	.38	.38
NA2O	3.88	3.56
K2O	3.10	1.87
P2O5	.02	0.00
H2O	5.36	16.93
	99.82	100.00

H_2O^+ : 5.29

H_2O^- : 0.07

QZ	37.73
OR	18.31
AB	32.83
AN	1.76
LC	0.00
NE	0.00
CO	.01
WO	0.00
EN	0.00
FS	0.00
EN	.09
FS	.87
FO	0.00
FA	0.00
MT	.97
IM	.18
HM	0.00
AP	.04
RT	0.00
VN	5.35
	98.21

A	82.1	DI	0.0
F	17.3	QZ	97.4
M	.4	HY	2.5

FE2O3/FEO .77011

OR	34.6	QZ	42.4
AB	62.0	OR	20.6
AN	3.3	AB	36.9

SIO2	75.95	78.90
AL2O	12.15	7.43
TIO2	.12	.09
FE2O	.67	.26
FEO	.92	.79
MNO	0.00	0.00
MGO	.02	.03
CAO	.30	.33
NA2O	4.26	4.29
K2O	3.46	2.29
P2O5	.02	0.00
H2O	1.60	5.54
	99.47	100.00

H_2O^+ : 1.50

H_2O^- : 0.10

QZ	36.82
OR	20.44
AB	36.04
AN	1.37
LC	0.00
NE	0.00
CO	0.00
WO	0.00
EN	0.00
FS	0.00
EN	.04
FS	.93
FO	0.00
FA	0.00
MT	.97
IM	.22
HM	0.00
AP	.04
RT	0.00
VN	1.59
	98.52

A	83.3	DI	0.0
F	16.4	QZ	97.3
M	.2	HY	2.6

FE2O3/FEO .72826

OR	35.3	QZ	39.4
AB	62.2	OR	21.9
AN	2.3	AB	38.6

SIO2	73.85	71.49
AL2O	11.95	6.81
TIO2	.13	.09
FE2O	.61	.22
FEO	.83	.67
MNO	.03	.02
MGO	.03	.04
CAO	.20	.20
NA2O	4.12	3.86
K2O	3.30	2.03
P2O5	.02	0.00
H2O	4.49	14.51
	99.56	100.00

H_2O^+ : 4.22

H_2O^- : 0.27

QZ	36.38
OR	19.50
AB	34.86
AN	.87
LC	0.00
NE	0.00
CO	.01
WO	0.00
EN	0.00
FS	0.00
EN	.07
FS	.86
FO	0.00
FA	0.00
MT	.88
IM	.24
HM	0.00
AP	.04
RT	0.00
VN	4.48
	98.23

A	84.0	DI	0.0
F	15.6	QZ	97.4
M	.3	HY	2.5

FE2O3/FEO .73493

OR	35.3	QZ	40.0
AB	63.1	OR	21.4
AN	1.5	AB	38.4

SIO2	73.65	71.78
AL2O	11.97	6.87
TIO2	.23	.16
FE2O	1.02	.37
FEO	.50	.40
MNO	0.00	0.00
MGO	.14	.20
CAO	.32	.33
NA2O	3.41	3.22
K2O	3.23	2.00
P2O5	.04	.01
H2O	4.49	14.60
	99.00	100.00

H_2O^+ : 3.89

H_2O^- : 0.60

QZ	40.59
OR	19.08
AB	28.85
AN	1.35
LC	0.00
NE	0.00
CO	.02
WO	0.00
EN	0.00
FS	0.00
EN	.34
FS	0.00
FO	0.00
FA	0.00
MT	.94
IM	.43
HM	.36
AP	.08
RT	0.00
VN	4.48
	96.59

A	80.9	DI	0.0
F	17.2	QZ	99.1
M	1.7	HY	.8

FE2O3/FEO 2.04000

OR	38.7	QZ	45.8
AB	58.5	OR	21.5
AN	2.7	AB	32.5

T-3 20-30

SIO2	74.40	77.21
AL2O	13.03	7.96
TIO2	.14	.10
FE2O	.84	.32
FEO	.84	.72
MNO	0.00	0.00
MGO	.02	.03
CAO	.20	.22
NA2O	4.02	4.04
K2O	3.12	2.06
P2O5	.02	0.00
H2O	3.10	7.27
	99.73	100.00

H_2O^+ : 2.93

H_2O^- : 0.17

QZ	38.32
OR	18.43
AB	34.01
AN	.87
LC	0.00
NE	0.00
CO	.02
WO	0.00
EN	0.00
FS	0.00
EN	.04
FS	.61
FO	0.00
FA	0.00
MT	1.21
IM	.26
HM	0.00
AP	.04
RT	0.00
VN	2.09
	95.97

A	81.5	DI	0.0
F	18.2	QZ	98.2
M	.2	HY	1.7

FE2O3/FEO 1.00000

OR	34.5	QZ	42.2
AB	63.7	OR	20.3
AN	1.6	AB	37.4

T-3 150-160

SIO2	74.05	72.39
AL2O	12.32	7.09
TIO2	.13	.09
FE2O	.78	.28
FEO	.78	.63
MNO	.04	.03
MGO	.02	.02
CAO	.35	.36
NA2O	3.68	3.48
K2O	3.24	2.02
P2O5	.02	0.00
H2O	4.15	13.54
	99.56	100.00

H_2O^+ : 3.90

H_2O^- : 0.25

QZ	39.15
OR	19.14
AB	31.13
AN	1.61
LC	0.00
NE	0.00
CO	.02
WO	0.00
EN	0.00
FS	0.00
EN	.04
FS	.64
FO	0.00
FA	0.00
MT	1.13
IM	.24
HM	0.00
AP	.04
RT	0.00
VN	4.14
	97.35

A	82.1	DI	0.0
F	17.5	QZ	98.2
M	.2	HY	1.7

FE2O3/FEO 1.00000

OR	36.8	QZ	43.7
AB	59.9	OR	21.4
AN	3.1	AB	34.8

T-4 310-320

SIO2	74.35	75.14
AL2O	12.14	7.23
TIO2	.12	.09
FE2O	1.00	.38
FEO	.64	.54
MNO	.03	.02
MGO	.02	.03
CAO	.32	.34
NA2O	4.22	4.13
K2O	3.60	2.32
P2O5	.02	0.00
H2O	2.89	9.75
	99.35	100.00

H_2O^+ : 2.67

H_2O^- : 0.22

QZ	35.21
OR	21.27
AB	35.70
AN	1.46
LC	0.00
NE	0.00
CO	0.00
WO	0.00
EN	0.00
FS	0.00
EN	.04
FS	.20
FO	0.00
FA	0.00
MT	1.44
IM	.22
HM	0.00
AP	.04
RT	0.00
VN	2.88
	98.54

A	83.3	DI	0.0
F	16.4	QZ	99.2
M	.2	HY	.7

FE2O3/FEO 1.56250

OR	36.3	QZ	38.1
AB	61.0	OR	23.0
AN	2.5	AB	38.7

T-5 50-70

SIO2	74.25	72.52
AL2O	11.95	6.87
TIO2	.15	.11
FE2O	.89	.32
FEO	.59	.48
MNO	0.00	0.00
MGO	.10	.14
CAO	.20	.20
NA2O	4.02	3.80
K2O	3.28	2.04
P2O5	.02	0.00
H2O	4.13	13.46
	99.58	100.00

H_2O^+ : 3.58

H_2O^- : 0.55

QZ	37.68
OR	19.38
AB	34.01
AN	.87
LC	0.00
NE	0.00
CO	.01
WO	0.00
EN	0.00
FS	0.00
EN	.24
FS	.10
FO	0.00
FA	0.00
MT	1.29
IM	.28
HM	0.00
AP	.04
RT	0.00
VN	4.12
	98.06

A	83.0	DI	0.0
F	15.8	QZ	99.0
M	1.1	HY	.9

FE2O3/FEO 1.50847

OR	35.7	QZ	41.3
AB	62.6	OR	21.2
AN	1.6	AB	37.3

T-4 50-60

SIO2	73.40	74.51
AL2O	11.95	7.15
TIO2	.12	.09
FE2O	.65	.24
FEO	.94	.79
MNO	0.00	0.00
MGO	.02	.03
CAO	.23	.25
NA2O	3.88	3.81
K2O	3.30	2.13
P2O5	.02	0.00
H2O	3.23	10.94
	97.74	100.00

H_2O^+ : 3.13

H_2O^- : 0.10

QZ	37.22
OR	19.50
AB	32.83
AN	1.02
LC	0.00
NE	0.00
CO	.01
WO	0.00
EN	0.00
FS	0.00
EN	.04
FS	.99
FO	0.00
FA	0.00
MT	.94
IM	.22
HM	0.00
AP	.04
RT	0.00
VN	3.22
	96.07

A	82.2	DI	0.0
F	17.4	QZ	97.2
M	.2	HY	2.7

FE2O3/FEO .69148

OR	36.5	QZ	41.5
AB	61.5	OR	21.7
AN	1.9	AB	36.6

T-3 50-60

SIO2	73.85	73.22
AL2O	12.12	7.08
TIO2	.14	.10
FE2O	.87	.32
FEO	.75	.62
MNO	.03	.02
MGO	.03	.04
CAO	.23	.24
NA2O	3.98	3.82
K2O	3.14	1.98
P2O5	.02	0.00
H2O	3.78	12.51
	98.94	100.00

H_2O^+ : 3.62

H_2O^- : 0.16

QZ	37.91
OR	18.55
AB	33.67
AN	1.02
LC	0.00
NE	0.00
CO	.01
WO	0.00
EN	0.00
FS	0.00
EN	.07
FS	.48
FO	0.00
FA	0.00
MT	1.26
IM	.26
HM	0.00
AP	.04
RT	0.00
VN	3.78
	97.10

A	81.9	DI	0.0
F	17.6	QZ	98.5
M	.3	HY	1.4

FE2O3/FEO 1.16000

OR	34.8	QZ	42.0
AB	63.2	OR	20.5
AN	1.9	AB	37.3

SIO2	72.05	69.51
AL2O	11.98	6.81
TIO2	.10	.07
FE2O	.64	.23
FEO	.71	.57
MNO	0.00	0.00
MGO	.05	.07
CAO	.29	.29
NA2O	3.26	3.04
K2O	3.26	2.00
P2O5	.03	.01
H2O	5.39	17.35
	97.76	100.00

H_2O^+ : 5.06

H_2O^- : 0.33

QZ	39.65
OR	19.26
AB	27.58
AN	1.26
LC	0.00
NE	0.00
CO	.02
WO	0.00
EN	0.00
FS	0.00
EN	.12
FS	.60
FO	0.00
FA	0.00
MT	.92
IM	.18
HM	0.00
AP	.06
RT	0.00
VN	5.38
	95.09

A	82.9	DI	0.0
F	16.3	QZ	98.1
M	.6	HY	1.8

FE2O3/FEO .90140

OR	40.0	QZ	45.8
AB	57.3	OR	22.2
AN	2.6	AB	31.8

SIO2	74.25	75.07
AL2O	12.22	7.28
TIO2	.13	.09
FE2O	.81	.30
FEO	.82	.69
MNO	.03	.02
MGO	.02	.03
CAO	.35	.37
NA2O	4.00	3.92
K2O	3.28	2.11
P2O5	.02	0.00
H2O	2.98	10.05
	98.91	100.00

H_2O^+ : 2.76

H_2O^- : 0.22

QZ	37.33
OR	19.38
AB	33.84
AN	1.61
LC	0.00
NE	0.00
CO	.01
WO	0.00
EN	0.00
FS	0.00
EN	.04
FS	.67
FO	0.00
FA	0.00
MT	1.17
IM	.24
HM	0.00
AP	.04
RT	0.00
VN	2.97
	97.37

A	82.2	DI	0.0
F	17.5	QZ	98.0
M	.2	HY	1.9

FE2O3/FEO .98780

OR	35.3	QZ	41.2
AB	61.7	OR	21.4
AN	2.9	AB	37.3

SIO2	74.00	72.16
AL2O	11.76	6.75
TIO2	.11	.08
FE2O	.66	.24
FEO	.73	.59
MNO	0.00	0.00
MGO	.04	.05
CAO	.26	.27
NA2O	3.98	3.76
K2O	3.42	2.12
P2O5	.02	0.00
H2O	4.28	13.93
	99.26	100.00

H_2O^+ : 4.08

H_2O^- : 0.20

QZ	36.85
OR	20.21
AB	33.67
AN	1.17
LC	0.00
NE	0.00
CO	.01
WO	0.00
EN	0.00
FS	0.00
EN	.09
FS	.61
FO	0.00
FA	0.00
MT	.95
IM	.20
HM	0.00
AP	.04
RT	0.00
VN	4.27
	98.13

A	84.4	DI	0.0
F	15.1	QZ	98.1
M	.4	HY	1.8

FE2O3/FEO .90410

OR	36.7	QZ	40.6
AB	61.1	OR	22.2
AN	2.1	AB	37.1

SIO2	73.40	73.14
AL2O	12.03	7.06
TIO2	.12	.08
FE2O	.77	.28
FEO	.77	.64
MNO	0.00	0.00
MGO	.04	.05
CAO	.26	.27
NA2O	3.88	3.74
K2O	3.08	1.95
P2O5	.04	.01
H2O	3.82	12.70
	98.21	100.00

H_2O^+ : 3.50

H_2O^- : 0.32

QZ	38.20
OR	18.20
AB	32.83
AN	1.05
LC	0.00
NE	0.00
CO	.01
WO	0.00
EN	0.00
FS	0.00
EN	.09
FS	.57
FO	0.00
FA	0.00
MT	1.11
IM	.22
HM	0.00
AP	.08
RT	0.00
VN	3.81
	96.24

A	82.2	DI	0.0
F	17.2	QZ	98.2
M	.4	HY	1.7

FE2O3/FEO 1.00000

OR	34.9	QZ	42.8
AB	63.0	OR	20.3
AN	2.0	AB	36.7

SIO2	73.80	72.52
AL2O	12.32	7.13
TIO2	.11	.08
FE2O	.60	.22
FEO	.96	.78
MNO	0.00	0.00
MGO	.03	.04
CAO	.23	.24
NA2O	4.00	3.81
K2O	3.16	1.98
P2O5	.02	0.00
H2O	4.01	13.15
	99.24	100.00

H_2O^+ : 3.86

H_2O^- : 0.15

QZ	37.40
OR	18.67
AB	33.84
AN	1.02
LC	0.00
NE	0.00
CO	.01
WO	0.00
EN	0.00
FS	0.00
EN	.07
FS	1.08
FO	0.00
FA	0.00
MT	.86
IM	.20
HM	0.00
AP	.04
RT	0.00
VN	4.00
	97.25

A	82.3	DI	0.0
F	17.2	QZ	96.9
M	.3	HY	3.0

FE2O3/FEO .62500

OR	34.8	QZ	41.5
AB	63.2	OR	20.7
AN	1.9	AB	37.6

C-3 43.6-45.6

SIO2	74.27	75.21
AL2O	12.31	7.34
TIO2	.11	.08
FE2O	.73	.27
FEO	.79	.66
MNO	0.00	0.00
MGO	.04	.06
CAO	.41	.44
NA2O	4.22	4.14
K2O	3.48	2.24
P2O5	.02	0.00
H2O	2.81	9.50
	99.19	100.00

H_2O^+ : 2.77

H_2O^- : 0.04

QZ	35.15
OR	20.56
AB	35.70
AN	1.91
LC	0.00
NE	0.00
CO	0.00
WO	0.00
EN	0.00
FS	0.00
EN	.09
FS	.66
FO	0.00
FA	0.00
MT	1.05
IM	.20
HM	0.00
AP	.04
RT	0.00
VN	2.80
	98.24

A	83.8	DI	0.0
F	15.7	QZ	97.8
M	.4	HY	2.1

FE2O3/FEO .92405

OR	35.3	QZ	38.4
AB	61.3	OR	22.4
AN	3.2	AB	39.0

C-2, 22-25

SIO2	72.32	72.89
AL2O	13.07	7.76
TIO2	.11	.08
FE2O	.76	.28
FEO	.79	.66
MNO	0.00	0.00
MGO	.02	.03
CAO	.38	.41
NA2O	4.02	3.92
K2O	3.24	2.08
P2O5	.02	0.00
H2O	3.52	11.84
	98.25	100.00

H_2O^+ : 3.29

H_2O^- : 0.23

QZ	35.39
OR	19.14
AB	34.01
AN	1.76
LC	0.00
NE	0.00
CO	.02
WO	0.00
EN	0.00
FS	0.00
EN	.04
FS	.64
FO	0.00
FA	0.00
MT	1.10
IM	.20
HM	0.00
AP	.04
RT	0.00
VN	3.51
	95.91

A	82.9	DI	0.0
F	16.8	QZ	98.0
M	.2	HY	1.9

FE2O3/FEO .96202

OR	34.8	QZ	39.9
AB	61.9	OR	21.6
AN	3.2	AB	38.4

T-4, 140-150

SIO2	72.47	71.45
AL2O	12.26	7.12
TIO2	.12	.08
FE2O	.73	.27
FEO	.88	.72
MNO	.03	.02
MGO	.03	.04
CAO	.35	.36
NA2O	3.82	3.65
K2O	3.30	2.07
P2O5	.03	.01
H2O	4.30	14.15
	98.32	100.00

H_2O^+ : 4.1

H_2O^- : 0.1

QZ	36.44
OR	19.50
AB	32.32
AN	1.55
LC	0.00
NE	0.00
CO	.01
WO	0.00
EN	0.00
FS	0.00
EN	.07
FS	.87
FO	0.00
FA	0.00
MT	1.05
IM	.22
HM	0.00
AP	.06
RT	0.00
VN	4.29
	96.44

A	81.9	DI	0.0
F	17.6	QZ	97.4
M	.3	HY	2.5

FE2O3/FEO .82954

OR	36.5	QZ	41.2
AB	60.5	OR	22.0
AN	2.9	AB	36.6

200T

SIO2	74.00	76.71
AL2O	12.30	7.51
TIO2	.12	.09
FE2O	.72	.28
FEO	.93	.80
MNO	0.00	0.00
MGO	.03	.04
CAO	.29	.32
NA2O	3.98	4.00
K2O	3.18	2.10
P2O5	.04	.01
H2O	2.34	8.09
	97.93	100.00

H_2O^+ : 2.19

H_2O^- : 0.15

QZ	37.63
OR	18.79
AB	33.67
AN	1.20
LC	0.00
NE	0.00
CO	.01
WO	0.00
EN	0.00
FS	0.00
EN	.07
FS	.91
FO	0.00
FA	0.00
MT	1.04
IM	.22
HM	0.00
AP	.08
RT	0.00
VN	2.34
	96.01

A	81.6	DI	0.0
F	17.9	QZ	97.4
M	.3	HY	2.5

FE2O3/FEO .77419

OR	35.0	QZ	41.7
Ab	62.7	OR	20.8
AN	2.2	AB	37.3

B-2, 12.8-15.8

SIO2	73.20	71.95
AL2O	12.60	7.29
TIO2	.12	.08
FE2O	.62	.22
FEO	1.02	.83
MNO	0.00	0.00
MGO	.03	.04
CAO	.29	.30
NA2O	3.78	3.60
K2O	3.16	1.98
P2O5	.02	0.00
H2O	4.16	13.65
	99.00	100.00

H_2O^+ : 4.00

H_2O^- : 0.16

QZ	37.91
OR	18.67
AB	31.98
AN	1.32
LC	0.00
NE	0.00
CO	.02
WO	0.00
EN	0.00
FS	0.00
EN	.07
FS	1.16
FO	0.00
FA	0.00
MT	.89
IM	.22
HM	0.00
AP	.04
RT	0.00
VN	4.15
	96.48

A	81.1	DI	0.0
F	18.4	QZ	96.8
M	.3	HY	3.1

FE2O3/FEO .60784

OR	35.9	QZ	42.8
AB	61.5	OR	21.0
AN	2.5	AB	36.1