

Petrogenesis of Lava from Wainama West, Mount Oku (CVL): Source Characterization and Magma Evolution

Wotchoko Pierre^{1,*}, Nkouathio David Guimollaire², Kouankap Nono Gus Djibril¹, Chenyi Marie-Louise Vohnyui^{1,2}, Guedjeo Christian Suh^{1,2}, Bulam Annyta Tangie¹, Tchokona Seuwui dieudonne³, Seplong Yannick^{1,3}

¹Department of Geology, Higher Teacher Training College, University of Bamenda, Bambili, Bamenda, Cameroon ²Department of Earth Sciences, Faculty of Sciences, University of Dschang, Dschang, Cameroon ³Department of Earth Sciences, Faculty of Sciences, University of Yaoundé 1, Yaoundé, Cameroon *Corresponding author: pierrewotchoko@yahoo.fr

Abstract The Wainama West area belongs to the Cameroon volcanic Line (CVL). Three petrographic types of lavas are identified: basanites, trachytes and rhyolites. Basanites with porphyritic texture are made up of minerals: plagioclase, clinopyroxene, olivine phenocrysts and opaque minerals within a groundmass; trachytes with microlitic-porphyritic texture are composed of phenocrysts of sanidine, hornblende, plagioclases, pyroxene and opaque minerals enclosed in a fine groundmass showing a preferred orientation. Rhyolite shows a microlitic-porphyritic texture made up of quartz, sanidine and opaque minerals in the groundmass. According to their geochemical behaviour, major elements show an enrichment in SiO₂ (42.7–70.7 wt.%), Al₂O₃ (13.7–16.6 wt.%), Na₂O (2.3–6.3 wt.%), K₂O (1.3–4.9 wt.%) and an impoverishment in MgO (8.3–0.02 wt.%) and CaO (10.0–0.5 wt.%) from basanite to rhyolite. Some binary diagrams indicate a good correlation with some minor elements (Cr, Ba, Zr, Sr, Rb, and Nb) against SiO₂. REE patterns of the rocks are characterized by a negative anomaly in Eu (0.3<Eu/Eu*<0.4) in basanite and weak negative anomaly in Eu (0.1<Eu/Eu*<0.2) from trachytes to rhyolites, with parallel profiles. The Wainama West lavas are found to have originated from a single primary melt similar to that of OIB and the continental basalt but with slightly higher Nb/Ta content. From the Dy/Yb vs La/Yb diagrams, the major processes resulting to the generation of this primary melt is the partial melting of garnet peridotite, of the high degree (11-12%). The Wainama West alkali lavas were formed in intraplate setting of continental part of the CVL.

Keywords: Wainama West, petrography, geochemistry, partial melting, garnet peridotite

Cite This Article: Wotchoko Pierre, Nkouathio David Guimollaire, Kouankap Nono Gus Djibril, Chenyi Marie-Louise Vohnyui, Guedjeo Christian Suh, Bulam Annyta Tangie, Tchokona Seuwui dieudonne, and Seplong Yannick, "Petrogenesis of Lava from Wainama West, Mount Oku (CVL): Source Characterization and Magma Evolution." *Journal of Geosciences and Geomatics*, vol. 5, no. 1 (2017): 1-11. doi: 10.12691/jgg-5-1-1.

1. Introduction

The Cameroon volcanic line (CVL) is one of the major tectono-magmatic features during the Cenozoic and Quaternary time in Africa [2,7,8,9]. The close to 2000 km long province is exposed in both oceanic and continental settings. The oceanic part of the CVL is composed of volcanic islands in the Gulf of Guinea: Pagalù, São Tomé, Príncipe, Bioko and seamounts (Figure 1). In the continental part, a series of grabens and horsts from Etinde and Mount Cameroon to Lake Chad ([6,11]) are occupied by volcanic fields, stratovolcanoes and plutonic–volcanic complexes [7]. This paper provides new investigations and analysis for the volcanic rocks in the Wainama West area, with the goal to clarify the origin of the lavas of Mount Oku in particular and the CVL in general.

2. Geological Setting

The study area is found on the western flank of Mount Oku which is part of the Oku volcanic group (OVG), situated between Babessi and Jakiri. It is located at latitude N06°3'0 - N06°4'0 and longitude E10°36'30 -E10°37'30 E. The OVG is a complex stratovolcanic edifice of 90 km across rising to a height of 3011m. About 2000m of lava pile have erupted here ranging from basalt through hawaite, mugearite to trachyte to rhyolites, high level intrusions and intercalated pyroclastics ([24,25]). Magmatic activity on this Mountain extends from 31My to present ([24]). Ancient lava of Mount Oku forms a bipolar series with alkaline basalt on the one hand, trachyte and rhyolite on the other hand. Recent volcanism formed craters and partially scoria cones, comprising many lakes like Nyos, Enep, Nyi, Wum and Oku [1]. According to [19], the oldest (24.79±0.11 My) felsic volcanism in the Western Cameroon Highland (WCH) occurred at Mount Oku. The enriched geochemical signatures (EM) of the Oku magmas derived from a sub-continental lithospheric mantle enriched in incompatible trace elements by ancient metasomatic processes [26].

3. Analytical Method

Thin sections of the representative rock samples were done in the Geotech Laboratories LtdVancouver Canada using conventional techniques. All rock samples were also coded and sent to ALS Chemex, South Africa for whole rock geochemistry. For the major elements, geochemical analyses, a prepared sample (0.200g) was added to lithium metaborate/lithium tetraborate flux (0.90g), mixed well and fused in a furnace at 1000°C. The resulting melt was then cooled and dissolved in 100ml of 4% HNO₃ / 2% HCl. This solution was then analyzed by ICP-AES and the results were corrected for spectral inter-element interferences. Oxide concentrations were calculated from

the determined elemental concentration and the result was reported in that format. The oxides were calculated in percentages with an upper limit of 100 and a lower limit of 0.01. These oxides included Al₂O₃, BaO, CaO, Cr₂O₃, MgO, MnO, P₂O₅, K₂O, SiO₂, Na₂O, SrO and TiO₂. For samples that were high in sulphides, they were substituted with peroxide fusion in order to obtain better results. For the loss on ignition (LOI) values, the samples were decomposed in thermal decomposition furnace and the analytical method was gravimetric. A prepared sample (1.0g) was placed in an oven at 1000°C for an hour, cooled and then weighted. The percent loss on ignition was calculated from the difference in weight. For trace elements, the samples were decomposed by lithium borate fusion (FUS-LI01) and the analytical method used was ICP-MS. A prepared sample (0.200g) was added to lithium borate flux (0.90g), mixed well and fused in a furnace at 1000°C. The resulting melt was then cooled and dissolved in 100ml of 4% HNO₃/2% HCl solution. This solution was then analysed by ICP-MS. This analysis included both the REE and trace elements. Analytical uncertainties vary from 0.1% to 0.04% for major elements to 0.5% for trace elements and from 0.01 to 0.5ppm for REE.



Figure 1. Location of the Wainama West area (the red square mark) along the Cameroon Volcanic Line (adapted after [13]). Location of seamounts after [4]. Inset bottom right is after [17]



Figure 2. Geologic map of the Wainama West area



Figure 3. TAS diagrams of Wainama West lavas [18]. The curve with the broken lines is the limit of [14] saparating the alkaline series from the subalkaline series

4. Results

4.1. Petrography and Nomenclature

The different rock formations in the Wainama West area are illustrated on the geologic map (Figure 2). TAS diagram [18] shows that all the samples fall within the basanite, trachyte and rhyolite fields with alkaline affinities (Figure 3). Basanite presents a microlitic porphyritic texture and is characterized by the following minerals: Plagioclases (46%) which are euhedral to subhedral ranging from <0.4-7mm. Olivine (30%) crystals which are euhedral to anhedral, ranging from 0.08-0.5mm. Some olivine crystals present evidence of indingsitization. The opaque minerals (8%) occur as inclusions within olivine and clinopyroxene crystals. They are subhedral to anhedral in shape with sizes from 0.06-3.2mm. Clinopyroxenes (16%) are subhedral to anhedral with a size range of 0.5-1.1mm.

Trachyte presents a microlitic porphyritic texture with mineral such as Sanidine (55%) with subhedral-euhedral shaped crystals. Their sizes range from 0.25-0.75mm. Plagioclases (28%) are both in the groundmass and phenocrysts. Opaque minerals (8%) are sub-rounded in shape and sometimes occur as inclusion in sanidine crystals. Clinopyroxenes (5%) are sub-euhedral with a size range between 1.5-4mm (Figure 4). Brown hornblendes (4%) occur in isolation and as inclusions in Sanidine. Rhyolite shows a microlithic-porphyritic texture with mineral such as Sanidines (60%) occur as euhedral or subhedral phenocrysts and also as microlites in the groundmass. Some large sanidine crystals contain inclusions of opaque minerals. Quartz (30%) occurs as sub-anhedral to anhedral phenocrysts and also in the groundmass. Groundmass (10%) contains micrograins of sanidine, opaque minerals and quartz (Figure 4).



Figure 4. Photomicrograph of rocks from Wainama West: (a and b) basanite; (c and d) trachytes; (d and e) rhyolite. (Ol=Olivine, Sa=Sanidine, Cpx=Clinopyroxene, Pl=Plagioclase, Qtz=Quartz and Ox=Opaque minerals)

4.2. Geochemistry

4.2.1. Major Elements

Results of the geochemical analysis for major elements are presented in Table 1. The major elements plotted against SiO_2 presents two trends (Figure 5). The increase of K₂O and Al₂O₃ is linked to increasing volume of modal plagioclase. The elements that show positive correlation indicated in (Figure 5) are Na₂O, which increases from basanite (ranging from 2.5%-2.56%) to trachyte (5.9 8%-6.33%) and K₂O with increasing trend from basanite (1.3%-1.48%) to rhyolite (4.66%-4.84%). The elements that show a negative correlation have a decreasing trend from basanite through trachyte to rhyolite. It can be seen that MgO in basanite ranges from 7.8%-8.255%, in rhyolite between 0.02%-0.08%. Its high deposition is linked to a crystallization of certain minerals like oxides which are encountered at varied proportions inside the lava and abundant in the basalt. Fe₂O₃ in basanite between 0.20%-1.83% and in rhyolites between 0.20%-0.50%. This decrease indicates quick precipitation of ferro-titano oxide for lava of Wainama West. CaO in basanite ranges between 9.27%-10% and in rhyolite between 0.6%-0.72%. This decreasing evolution can be explained by the incorporation of Ca during the fractionation of

clinopyroxene and plagioclase abundant in trachyte and rhyolite of Wainama West. P_2O_5 in basanite ranges between 0.76%-0.7% and in rhyolite between 1.15%-1.16%. This is probably the fractionation of apatite in basanite but was not seen in thin section.

						Bas	anite					
SAMPLE	W17	W18	W19	W20	W21	W22	W25	W26	W27	W28	W29	W30
SiO ₂	43.4	42.7	44.3	43.4	43.3	43.2	43.9	43.6	43.2	43.9	43.2	43.2
Al ₂ O ₂	14.2	14	14.5	14.2	14.2	14.2	14.4	14.3	14.1	14.4	14.2	14.2
FeaOa	13.4	13.2	13.7	13.5	13.5	13.3	13.6	13.5	13.5	13.9	13.6	13.7
$C_{2}O_{3}$	0 / 3	0.27	0.6	0.47	0.4	0.41	10	0.01	0.74	0.0	0.78	0.8
MaO	9.43	9.27	9.0	9.47	9.4	9.41	7.05	9.91 7.01	9.74	9.9 7 01	9.70	9.8 7.70
MgO	8.28	8.10	8.18	8	8.15	8.25	7.95	7.91	7.91	7.81	7.81	7.79
Na ₂ O	2.47	2.46	2.55	2.42	2.5	2.43	2.28	2.27	2.49	2.56	2.46	2.37
K ₂ O	1.27	1.26	1.3	1.29	1.26	1.26	1.42	1.43	1.42	1.48	1.44	1.46
Cr_2O_3	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.06	0.03	0.07
TiO ₂	3.47	3.43	3.54	3.47	3.46	3.47	3.52	3.49	3.45	3.5	3.45	3.45
MnO	0.18	0.18	0.19	0.19	0.19	0.18	0.19	0.18	0.19	0.19	0.19	0.19
P2OF	0.77	0.76	0.79	0.77	0.77	0.76	0.77	0.77	0.76	0.79	0.77	0.77
SrO	0.1	0.1	0.1	0.1	0.1	0.70	0.12	0.13	0.11	0.11	0.11	0.11
Ba	0.1	0.05	0.1	0.1	0.1	0.1	0.12	0.15	0.11	0.11	0.11	0.11
DaU LOL	0.05	0.05	0.00	0.00	0.05	0.00	0.00	0.05	0.03	0.00	0.03	0.03
LOI	2.75	2.6	2.73	2.76	2.65	2.71	2.24	2.31	1.51	1.48	1.66	1.92
Total	99.8	98.2	102	99.6	99.5	99.3	100	99.8	98.5	100	98.7	99
CIPW												
Quartz	-	-	-	-	-	-	-	-	-	-	-	-
Orthose	7,73	7.79	7.78	7.87	7.69	7.71	8.54	8.67	8 66	8.87	8 77	8.89
Albite	18.2	18	187	18.5	183	183	16.8	16.8	15 0	15 0	15 0	15 0
Anorthito	216.2	245	210.7	24.0	245	240	25.0	25 1	13.7	13.7	24	2/ /
Amortine	24.0	24.3	∠4.0	∠4.9	24.3	∠4.ð	23.3	23.1	23.8	23.ð	24	∠4.4
Acmite	-	-	-	-	-	-	-	-	-	-	-	-
Na metasilicate	-	-	-	-	-	-	-	-	-	-	-	-
Nepheline	1.8	2.05	1.7	1.42	1.92	1.63	1.54	1.57	3.14	3.32	3.03	2.59
Diopside	15.1	15.1	15.1	15.1	15.2	15	16.5	16.5	17.1	17.1	17.1	16.9
Hypersthene	-	-	-	-	-	-	-	-	-	-	-	-
Olivine	21.3	21.3	20.9	20.9	21.2	21.2	20.1	20	20.1	19.8	19.9	20.1
Magnetite	2 65	2 65	2 65	2.66	2 66	2.63	2 65	2 65	2 67	2 69	2.68	27
Ilmanita	6 70	6.81	6.81	6.81	6.70	6.83	6.81	6.8	676	674	6.76	6.75
Amotito	1.04	1.84	1.05	1.84	1.04	1.82	1.82	1.02	1.82	1.96	1.94	1.94
Apathe	1.04	1.64	1.65	1.64	1.04	1.62	1.62	1.05	1.62	1.00	1.64	1.64
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100
DI	27.7	27.8	28.2	27.8	27.9	27.6	26.9	27.1	27.7	28	27.7	27.4
					-							
				Tra	chyte					Rh	yolite	
SAMPLE	W33	W34	W35	Trac W36	chyte W37	W38	W1	W2	W3	Rhy W4	yolite W5	W6
SAMPLE SiO ₂	W33 66.2	W34 66.2	W35 66.5	Trac W36 65.6	w 37 65.7	W38 64.9	W1 68.6	W2 68.9	W3 69.8	Rh W4 69.9	volite W5 70.7	W6 69.4
SAMPLE SiO ₂ Al ₂ O ₃	W33 66.2 13.8	W34 66.2 13.8	W35 66.5 13.8	Trac W36 65.6 13.7	chyte W37 65.7 13.7	W38 64.9 13.5	W1 68.6 16.6	W2 68.9 16.5	W3 69.8 15.8	Rhy W4 69.9 15.8	yolite W5 70.7 15.9	W6 69.4 15.8
SAMPLE SiO ₂ Al ₂ O ₃ Fe ₂ O ₃	W33 66.2 13.8 6.74	W34 66.2 13.8 7.05	W35 66.5 13.8 6.9	Trac W36 65.6 13.7 7.04	chyte W37 65.7 13.7 6.74	W38 64.9 13.5 6.85	W1 68.6 16.6 2.12	W2 68.9 16.5 1.85	W3 69.8 15.8 1.95	Rhy W4 69.9 15.8 1.14	yolite W5 70.7 15.9 0.86	W6 69.4 15.8 1.68
SAMPLE SiO2 Al2O3 Fe2O3 CaO	W33 66.2 13.8 6.74 0.64	W34 66.2 13.8 7.05 0.62	W35 66.5 13.8 6.9 0.67	Trac W36 65.6 13.7 7.04 0.6	chyte W37 65.7 13.7 6.74 0.54	W38 64.9 13.5 6.85 0.71	W1 68.6 16.6 2.12 0.7	W2 68.9 16.5 1.85 0.68	W3 69.8 15.8 1.95 0.63	Rhy W4 69.9 15.8 1.14 0.66	yolite W5 70.7 15.9 0.86 0.6	W6 69.4 15.8 1.68 0.72
SAMPLE SiO2 Al2O3 Fe2O3 CaO MaO	W33 66.2 13.8 6.74 0.64 0.22	W34 66.2 13.8 7.05 0.62 0.21	W35 66.5 13.8 6.9 0.67 0.22	Trac W36 65.6 13.7 7.04 0.6 0.19	chyte W37 65.7 13.7 6.74 0.54 0.17	W38 64.9 13.5 6.85 0.71 0.22	W1 68.6 16.6 2.12 0.7 0.06	W2 68.9 16.5 1.85 0.68 0.06	W3 69.8 15.8 1.95 0.63 0.03	Rhy W4 69.9 15.8 1.14 0.66 0.02	yolite W5 70.7 15.9 0.86 0.6 0.02	W6 69.4 15.8 1.68 0.72 0.1
SAMPLE SiO ₂ Al ₂ O ₃ Fe ₂ O ₃ CaO MgO Na O	W33 66.2 13.8 6.74 0.64 0.22 6.08	W34 66.2 13.8 7.05 0.62 0.21 6 12	W35 66.5 13.8 6.9 0.67 0.22 6 13	Trae W36 65.6 13.7 7.04 0.6 0.19 6.04	chyte W37 65.7 13.7 6.74 0.54 0.17 6.05	W38 64.9 13.5 6.85 0.71 0.22 5.08	W1 68.6 16.6 2.12 0.7 0.06 6 23	W2 68.9 16.5 1.85 0.68 0.06 6.32	W3 69.8 15.8 1.95 0.63 0.03 6 00	Rhy W4 69.9 15.8 1.14 0.66 0.02 6.08	yolite W5 70.7 15.9 0.86 0.6 0.02 6 11	W6 69.4 15.8 1.68 0.72 0.1 6.08
SAMPLE SiO ₂ Al ₂ O ₃ Fe ₂ O ₃ CaO MgO Na ₂ O	W33 66.2 13.8 6.74 0.64 0.22 6.08	W34 66.2 13.8 7.05 0.62 0.21 6.12	W35 66.5 13.8 6.9 0.67 0.22 6.13	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04	chyte W37 65.7 13.7 6.74 0.54 0.17 6.05 4.94	W38 64.9 13.5 6.85 0.71 0.22 5.98	W1 68.6 16.6 2.12 0.7 0.06 6.33	W2 68.9 16.5 1.85 0.68 0.06 6.32	W3 69.8 15.8 1.95 0.63 0.03 6.09	Rhy W4 69.9 15.8 1.14 0.66 0.02 6.08	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.72	W6 69.4 15.8 1.68 0.72 0.1 6.08
SAMPLE SiO ₂ Al ₂ O ₃ Fe ₂ O ₃ CaO MgO Na ₂ O K ₂ O	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.51	chyte W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72	Rhy W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67
$\begin{tabular}{lllllllllllllllllllllllllllllllllll$	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03	war 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01	Rhy W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01
$\begin{tabular}{lllllllllllllllllllllllllllllllllll$	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51	W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67
SAMPLE SiO2 Al2O3 Fe2O3 CaO MgO Na2O K2O Cr2O3 TiO2 MnO	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29	W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03
$\begin{tabular}{lllllllllllllllllllllllllllllllllll$	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05	W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15
SAMPLE SiO2 Al2O3 Fe2O3 CaO MgO Na2O K2O Cr2O3 TiO2 MnO P2O5 SrO	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01	W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03	Rhy W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03
SAMPLE SiO2 Al2O3 Fe2O3 CaO MgO Na2O K2O Cr2O3 TiO2 MnO P2O5 SrO BaO	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.02	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.02	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02	W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.026 0.01 0.03	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 0.08	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.03	Rhy W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 0.08	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 0.08
SAMPLE SiO2 Al2O3 Fe2O3 CaO MgO Na2O K2O C12O3 TiO2 MnO P2O5 SrO BaO LOI	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.02 1.55	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.02 1.87	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66	W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 0.08 1.57	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.08 1.55	Rhy W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 0.08 1.27	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 0.15 0.03 1.58
SAMPLE SiO2 Al2O3 Fe2O3 CaO MgO Na2O K2O Cr2O3 TiO2 MnO P2O5 SrO BaO LOI	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.02 1.55	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.02 1.87	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66	W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.01 0.03 1.49	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 0.03 1.57	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.03	Rhy W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 0.08 1.27	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 1.58 1.58
SAMPLE SiO2 Al2O3 Fe2O3 CaO MgO Na2O K2O Cr2O3 TiO2 MnO P2O5 SrO BaO LOI Total	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.02 1.55 101	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.02 1.87 102	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101	W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.5	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 0.08 1.57 102	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.08 1.55 102	Rhy W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 0.08 1.27 100	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 1.58 1.58
SAMPLE SiO2 Al2O3 Fe2O3 CaO MgO Na2O K2O Cr2O3 TiO2 MnO P2O5 SrO BaO LOI Total CPW	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.02 1.55 101	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.02 1.87 102	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101	W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.01 0.03 1.49 100	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.5	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 0.08 1.57 102	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.08 1.55 102	Rhy W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 0.08 1.27 100	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 162	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 1.58 1.58 101
SAMPLE SiO2 Al2O3 Fe2O3 CaO MgO Na2O K2O Cr2O3 TiO2 MnO P2O5 SrO BaO LOI Total CIPW Quartz	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.02 1.55 101 9.87 2.87	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.02 1.87 102 9.69	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101 9.45	W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49 100	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.5	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 0.08 1.57 102	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 1.55 102 14.8	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 0.08 1.27 100	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 16.2	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 0.08 1.58 101
SAMPLE SiO ₂ Al ₂ O ₃ Fe ₂ O ₃ CaO MgO Na ₂ O K ₂ O Cr ₂ O ₃ TiO ₂ MnO P ₂ O ₅ SrO BaO LOI Total CIPW Quartz Orthose	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.02 1.55 101 9.87 28.8	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.02 1.87 102 9.69 28.9	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101 9.45 28.9	war W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49 100	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.5 9.56 28.8	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.01 0.03 0.03 0.08 1.57 102 12 28.5	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 1.55 102 14.8 27.9	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 0.08 1.27 100	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 16.2 28	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 1.58 101 14.6 27.8
$\begin{array}{c} \text{SAMPLE} \\ \text{SiO}_2 \\ \text{Al}_2\text{O}_3 \\ \text{Fe}_2\text{O}_3 \\ \text{CaO} \\ \text{MgO} \\ \text{Na}_2\text{O} \\ \text{CaO} \\ \text{MgO} \\ \text{Na}_2\text{O} \\ \text{CaO} \\ \text{Cr}_2\text{O}_3 \\ \text{TiO}_2 \\ \text{MnO} \\ \text{P}_2\text{O}_5 \\ \text{SrO} \\ \text{BaO} \\ \text{LOI} \\ \hline \hline \text{Total} \\ \hline \hline \hline \\ $	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.02 1.55 101 9.87 28.8 44	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101 9.36 29.1 43.7	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.02 1.87 102 9.69 28.9 43.7	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101 9.45 28.9 43.8	byte W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49 100 9.96 29 43.9	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.5 9.56 28.8 43.6	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102 11.4 28.6 53.5	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.01 0.68 0.03 0.03 0.03 1.57 102 12 28.5 53.5	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 1.55 102 14.8 27.9 51.6	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.016 0.03 0.08 1.27 100 15.7 27.8 51.9	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 16.2 28 51.8	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 1.58 101 14.6 27.8 51.8
SAMPLE SiO ₂ Al ₂ O ₃ Fe ₂ O ₃ CaO MgO Na ₂ O K ₂ O Cr ₂ O ₃ TiO ₂ MnO P ₂ O ₅ SrO BaO LOI Total CIPW Quartz Orthose Albite Anorthite	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.02 1.55 101 9.87 28.8 44	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101 9.36 29.1 43.7	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.02 1.87 102 9.69 28.9 43.7	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101 9.45 28.9 43.8	Wyte W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49 100 9.96 29 43.9	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.5 9.56 28.8 43.6	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102 11.4 28.6 53.5 2.45	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 1.57 102 12 28.5 53.5 2.39	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 1.55 102 14.8 27.9 51.6 1.84	Rhy W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 0.08 1.27 100 15.7 27.8 51.9 2.07	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 16.2 28 51.8 1.99	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 1.58 1.01 14.6 27.8 51.8 2.04
SAMPLE SiO ₂ Al ₂ O ₃ Fe ₂ O ₃ CaO MgO Na ₂ O K ₂ O C1 ₂ O ₃ TiO ₂ MnO P ₂ O ₅ SrO BaO LOI Total CIPW Quartz Orthose Albite Anorthite Acmite	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.25 101 9.87 28.8 44 - 3.67	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.52 0.27 0.05 0.01 0.02 1.87 102 9.69 28.9 43.7 - 3.73	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101 9.45 28.9 43.8 - 3.85	byte W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49 100 9.96 29 43.9 - 3.7	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.5 9.56 28.8 43.6 - 3.79	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102 11.4 28.6 53.5 2.45	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 1.57 102 12 28.5 53.5 2.39	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.08 1.55 102 14.8 27.9 51.6 1.84	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 0.08 1.27 100 15.7 27.8 51.9 2.07	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 16.2 28 51.8 1.99	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 1.58 101 14.6 27.8 51.8 2.04
SAMPLE SiO ₂ Al ₂ O ₃ Fe ₂ O ₃ CaO MgO Na ₂ O K ₂ O Cr ₂ O ₃ TiO ₂ MnO P ₂ O ₅ SrO BaO LOI Total CIPW Quartz Orthose Albite Anorthite Acmite Na metasilicate	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.25 101 9.87 28.8 44 - 3.67 0.84 -	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101 9.36 29.1 43.7 - 3.82 0.89	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.52 0.27 0.05 0.01 0.02 1.87 102 9.69 28.9 43.7 - 3.73 0.91	Trad W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101 9.45 28.9 43.8 - 3.85 0.81	byte W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49 100 9.96 29 43.9 - 3.7 0.89	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.5 9.56 28.8 43.6 - 3.79 0.9	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102 11.4 28.6 53.5 2.45	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 0.08 1.57 102 12 28.5 53.5 2.39	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.03 1.05 102 14.8 27.9 51.6 1.84	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 0.08 1.27 100 15.7 27.8 51.9 2.07	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 16.2 28 51.8 1.99 -	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 1.58 101 14.6 27.8 51.8 2.04
SAMPLE SiO ₂ Al ₂ O ₃ Fe ₂ O ₃ CaO MgO Na ₂ O K ₂ O Cr ₂ O ₃ TiO ₂ MnO P ₂ O ₅ SrO BaO LOI Total CIPW Quartz Orthose Albite Anorthite Acmite Na metasilicate Nepheline	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.02 1.55 101 9.87 28.8 44 - 3.67 0.84	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.02 1.87 102 9.69 28.9 43.7 - 3.73 0.91	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101 9.45 28.9 43.8 - 3.85 0.81	byte W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49 100 9.96 29 43.9 - 3.7 0.89	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.5 9.56 28.8 43.6 - 3.79 0.9	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102 11.4 28.6 53.5 2.45	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 0.08 1.57 102 12 28.5 53.5 2.39 -	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.03 1.05 102 14.8 27.9 51.6 1.84	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.67 0.01 0.67 0.03 0.08 1.27 100 15.7 27.8 51.9 2.07 -	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 16.2 28 51.8 1.99 - -	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 0.15 103 14.6 27.8 51.8 2.04
SAMPLE SiO ₂ Al ₂ O ₃ Fe ₂ O ₃ CaO MgO Na ₂ O K ₂ O Cr ₂ O ₃ TiO ₂ MnO P ₂ O ₅ SrO BaO LOI Total CIPW Quartz Orthose Albite Anorthite Acmite Na metasilicate Nepheline Dionside	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.02 1.55 101 9.87 28.8 44 - 3.67 0.84	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.02 1.87 102 9.69 28.9 43.7 - 3.73 0.91 2.65	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101 9.45 28.9 43.8 - 3.85 0.81 - 2.37	byte W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49 100 9.96 29 43.9 - 3.7 0.89 - 2.11	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.56 28.8 43.6 - 3.79 0.9 - 2.89	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 0.08 1.57 102 12 28.5 53.5 2.39 - - 0.01	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.08 1.55 102	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 0.08 1.27 100 15.7 27.8 51.9 2.07 - - 0.15	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 16.2 28 51.8 1.99 - - 0.01	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 0.08 1.58 101
SAMPLE SiO ₂ Al ₂ O ₃ Fe ₂ O ₃ CaO MgO Na ₂ O CaO MgO Na ₂ O Cr ₂ O ₃ TiO ₂ MnO P ₂ O ₅ SrO BaO LOI Total CIPW Quartz Orthose Albite Anorthite Acmite Na metasilicate Nepheline Diopside	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.02 1.55 101 9.87 28.8 44 - 3.67 0.84 - 2.53 0.10	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101 9.36 29.1 43.7 - 3.82 0.89 - 2.43 0.64	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.02 1.87 102 9.69 28.9 43.7 - 3.73 0.91 - 2.65 0.22	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101 9.45 28.9 43.8 - 3.85 0.81 - 2.37 0.70	byte W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49 100 9.96 29 43.9 - 3.7 0.89 - 2.11 0.27	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.56 28.8 43.6 - 3.79 0.9 - 2.89 2.89	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 0.08 1.57 102 28.5 53.5 2.39 - - - 0.01 1.41	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.08 1.55 102 14.8 27.9 51.6 1.84 - - 0.22 125	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.67 0.03 0.08 1.27 100 15.7 27.8 51.9 2.07 - - 0.15 0.21	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 16.2 28 51.8 1.99 - - 0.01 0.02	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 0.08 1.58 101
SAMPLE SiO ₂ Al ₂ O ₃ Fe ₂ O ₃ CaO MgO Na ₂ O Cr ₂ O ₃ TiO ₂ MnO P ₂ O ₅ SrO BaO LOI Total CIPW Quartz Orthose Albite Anorthite Acmite Na metasilicate Nepheline Diopside Hypersthene	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.05 0.01 0.02 1.55 101 9.87 28.8 44 - 3.67 0.84 - 2.53 9.19	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101 9.36 29.1 43.7 - 3.82 0.89 - 2.43 9.64	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.02 1.87 102 9.69 28.9 43.7 - 3.73 0.91 - 2.65 9.32	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101 9.45 28.9 43.8 - 3.85 0.81 - 2.37 9.79	byte W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49 100 9.96 29 43.9 - 3.7 0.89 - 2.11 9.37	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.56 28.8 43.6 - 3.79 0.9 - 2.89 9.38	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102 11.4 28.6 53.5 2.45 - - 0.04 1.75	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 0.08 1.57 102 12 28.5 53.5 2.39 - - 0.01 1.41	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.03 1.55 102 14.8 27.9 51.6 1.84 - 0.22 1.35	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 0.08 1.27 100 15.7 27.8 51.9 2.07 - 0.15 0.31	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 16.2 28 51.8 1.99 - - 0.01 0.03	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 0.15 0.03 1.58 101 14.6 27.8 51.8 2.04 - - 0.49 1.05
SAMPLE SiO ₂ Al ₂ O ₃ Fe ₂ O ₃ CaO MgO Na ₂ O K ₂ O Cr ₂ O ₃ TiO ₂ MnO P ₂ O ₅ SrO BaO LOI Total CIPW Quartz Orthose Albite Anorthite Acmite Na metasilicate Nepheline Diopside Hypersthene Olivine	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.02 1.55 101 9.87 28.8 44 - - 3.67 0.84 - 2.53 9.19	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101 9.36 29.1 43.7 - 3.82 0.89 - 2.43 9.64	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.027 0.05 0.01 0.02 1.87 102 9.69 28.9 43.7 - 3.73 0.91 - 2.65 9.32	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101 9.45 28.9 43.8 - 3.85 0.81 - 2.37 9.79	byte W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49 100 9.96 29 43.9 - 3.7 0.89 - 2.11 9.37	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.5 9.56 2.88 43.6 - 3.79 0.9 2.89 9.38	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102 11.4 28.6 53.5 2.45 - 0.04 1.75	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 1.57 102 12 28.5 53.5 2.39 - - 0.01 1.41	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.08 1.55 102 14.8 27.9 51.6 1.84 - 0.22 1.35	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 0.08 1.27 100 15.7 27.8 51.9 2.07 - 0.15 0.31	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 16.2 28 51.8 1.99 - - 0.01 0.03 - -	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 0.15 0.03 1.58 1.01 14.6 27.8 51.8 2.04 - - 0.49 1.05
SAMPLE SiO2 Al2O3 Fe2O3 CaO MgO Na2O K2O CT2O3 TiO2 MnO P2O5 SrO BaO LOI Total CIPW Quartz Orthose Albite Anorthite Acmite Na metasilicate Nepheline Diopside Hypersthene Olivine Magnetite	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.25 101 9.87 28.8 44 - 3.67 0.84 - 2.53 9.19 - 0	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101 9.36 29.1 43.7 - 3.82 0.89 - 2.43 9.64 - 0	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.52 0.27 0.05 0.01 0.02 1.87 102 9.69 28.9 43.7 - 3.73 0.91 - 2.65 9.32 - 0	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101 9.45 28.9 43.8 - 3.85 0.81 - 2.37 9.79 - 0	byte W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49 100 9.96 29 43.9 - 3.7 0.89 - 2.11 9.37 0	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.5 9.56 28.8 43.6 - 3.79 0.9 - 2.89 9.38 - 0	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102 11.4 28.6 53.5 2.45 - 0.04 1.75 - 0.73 <td>W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 0.03 1.57 102 12 28.5 53.5 2.39 - 0.01 1.41 - 0.63</td> <td>W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.08 1.55 102 14.8 27.9 51.6 1.84 - 0.22 1.35 - 0.67</td> <td>Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 1.27 100 15.7 27.8 51.9 2.07 - 0.15 0.31 - 0.39 </td> <td>yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 16.2 28 51.8 1.99 - - 0.01 0.03 - 0.3</td> <td>W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 0.15 0.03 1.58 101 14.6 27.8 51.8 2.04 - 0.49 1.05 - 0.58</td>	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 0.03 1.57 102 12 28.5 53.5 2.39 - 0.01 1.41 - 0.63	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.08 1.55 102 14.8 27.9 51.6 1.84 - 0.22 1.35 - 0.67	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 1.27 100 15.7 27.8 51.9 2.07 - 0.15 0.31 - 0.39	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 16.2 28 51.8 1.99 - - 0.01 0.03 - 0.3	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 0.15 0.03 1.58 101 14.6 27.8 51.8 2.04 - 0.49 1.05 - 0.58
SAMPLE SiO ₂ Al ₂ O ₃ Fe ₂ O ₃ CaO MgO Na ₂ O K ₂ O Cr ₂ O ₃ TiO ₂ MnO P ₂ O ₅ SrO BaO LOI Total CIPW Quartz Orthose Albite Anorthite Acmite Na metasilicate Nepheline Diopside Hypersthene Olivine Magnetite Ilmenite	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.53 0.27 0.05 0.01 0.25 101 9.87 28.8 44 - 3.67 0.84 - - 0 1.01 -	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101 9.36 29.1 43.7 - 3.82 0.89 - 2.43 9.64 - 0 1.01	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.52 0.27 0.05 0.01 0.02 1.87 102 9.69 28.9 43.7 - 3.73 0.91 - 2.65 9.32 - 0 0.99	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101 9.45 28.9 43.8 - 3.85 0.81 - 0 0.98	byte W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49 100 9.96 29 43.9 - 3.7 0.89 - 2.11 9.37 0 1	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.5 9.56 28.8 43.6 - 3.79 0.9 2.89 9.38 0 0.99	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102 11.4 28.6 53.5 2.45 - 0.04 1.75 0.73 1.29	W2 68.9 16.5 1.85 0.68 0.01 0.68 0.04 0.15 0.03 0.03 1.57 102 12 28.5 53.5 2.39 - 0.01 1.41 - 0.63 1.29	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.04 0.16 0.03 0.04 0.16 0.03 0.08 1.55 102 14.8 27.9 51.6 1.84 - 0.22 1.35 - 0.67 1.29	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 0.08 1.27 100 15.7 27.8 51.9 2.07 - 0.15 0.31 - 0.39 1.28	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 16.2 28 51.8 1.99 - - 0.01 0.03 - 0.3 1.28	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 0.15 0.03 0.15 0.03 0.15 0.03 0.08 1.58 101 14.6 27.8 51.8 2.04 - 0.49 1.05 - 0.58 1.28
SAMPLE SiO ₂ Al ₂ O ₃ Fe ₂ O ₃ CaO MgO Na ₂ O CaO MgO Na ₂ O CaO MgO Na ₂ O SaO Cr ₂ O ₃ TiO ₂ MnO P ₂ O ₃ SrO BaO LOI Total CIPW Quartz Orthose Albite Anorthite Anorthite Anorthite Anorthite Na metasilicate Nepheline Diopside Hypersthene Olivine Magnetite Ilmenite Apatite	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.02 1.55 101 9.87 28.8 44 - 2.53 9.19 0 1.01 0.12 -	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101 9.36 29.1 43.7 - 3.82 0.89 - 2.43 9.64 - 0 1.01 0.12	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.02 1.87 102 9.69 28.9 43.7 - 3.73 0.91 - 0 0.92 0 0.99 0.12	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101 9.45 28.9 43.8 - 3.85 0.81 - 0 0.98 0.12	byte W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49 100 9.96 29 43.9 - 3.7 0.89 - 2.11 9.37 0 1 0.12	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.56 28.8 43.6 - 2.89 9.38 0 0.99 0.12	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102 11.4 28.6 53.5 2.45 - 0.04 1.75 0.73 1.29 0.35	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 0.03 0.08 1.57 102 12 28.5 53.5 2.39 - 0.01 1.41 0.63 1.29 0.35	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.08 1.55 102 14.8 27.9 51.6 1.84 - 0.22 1.35 0.67 1.29 0.37	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.16 0.03 0.08 1.27 100 15.7 27.8 51.9 2.07 - 0.15 0.31 - 0.39 1.28 0.37	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 16.2 28 51.8 1.99 - - 0.01 0.03 - 0.3 1.28 0.35	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 0.08 1.58 101 14.6 27.8 51.8 2.04 - 0.49 1.05 0.58 1.28 0.35
SAMPLE SiO ₂ Al ₂ O ₃ Fe ₂ O ₃ CaO MgO Na ₂ O K ₂ O Cr ₂ O ₃ TiO ₂ MnO P ₂ O ₅ SrO BaO LOI Total CIPW Quartz Orthose Albite Anorthite Acmite Na metasilicate Nepheline Diopside Hypersthene Olivine Magnetite Ilmenite Apatite TOTAL	W33 66.2 13.8 6.74 0.64 0.22 6.08 4.85 0.01 0.53 0.27 0.05 0.01 0.02 1.55 101 9.87 28.8 44 - 3.67 0.84 - 2.53 9.19 - 0 1.01 0.12 100	W34 66.2 13.8 7.05 0.62 0.21 6.12 4.91 0.03 0.53 0.27 0.05 0.01 0.02 1.49 101 9.36 29.1 43.7 - 3.82 0.89 - 2.43 9.64 - 0 1.01 0.12 100	W35 66.5 13.8 6.9 0.67 0.22 6.13 4.9 0.01 0.52 0.27 0.05 0.01 0.02 1.87 102 9.69 28.9 43.7 - 3.73 0.91 - 0 0.92 0 0.99 0.12 100	Trac W36 65.6 13.7 7.04 0.6 0.19 6.04 4.83 0.03 0.51 0.29 0.05 0.01 0.02 1.66 101 9.45 28.9 43.8 - 3.85 0.81 - 0 0.98 0.12 100	byte W37 65.7 13.7 6.74 0.54 0.17 6.05 4.84 0.01 0.52 0.26 0.05 0.01 0.03 1.49 100 9.96 29 43.9 - 3.7 0.89 - 0.11 9.37 0 1 0.12 100	W38 64.9 13.5 6.85 0.71 0.22 5.98 4.77 0.02 0.51 0.27 0.05 0.01 0.02 1.75 99.56 28.8 43.6 - 3.79 0.9 - 2.89 9.38 - 0 0.99 0.12 100	W1 68.6 16.6 2.12 0.7 0.06 6.33 4.84 0.01 0.68 0.05 0.15 0.03 0.09 1.68 102 11.4 28.6 53.5 2.45 - 0.04 1.75 - 0.73 1.29 0.35 100	W2 68.9 16.5 1.85 0.68 0.06 6.32 4.83 0.01 0.68 0.04 0.15 0.03 0.03 0.03 1.57 102 12 28.5 53.5 2.39 - - 0.01 1.41 - 0.63 1.29 0.35 100	W3 69.8 15.8 1.95 0.63 0.03 6.09 4.72 0.01 0.68 0.04 0.16 0.03 0.08 1.55 102 14.8 27.9 51.6 1.84 - 0.22 1.35 - 0.67 1.29 0.37 100	Rhg W4 69.9 15.8 1.14 0.66 0.02 6.08 4.66 0.01 0.67 0.01 0.67 0.01 0.67 0.016 0.03 0.08 1.27 100 15.7 27.8 51.9 2.07 - - 0.15 0.31 - 0.39 1.28 0.37 100	yolite W5 70.7 15.9 0.86 0.6 0.02 6.11 4.73 0.01 0.67 0.01 0.15 0.03 0.08 1.18 101 16.2 28 51.8 1.99 - - 0.01 0.03 - 0.3 1.28 0.35 100	W6 69.4 15.8 1.68 0.72 0.1 6.08 4.67 0.01 0.67 0.03 0.15 0.03 0.08 1.58 101 14.6 27.8 51.8 2.04 - 0.49 1.05 - 0.58 1.28 0.35 100



4.2.2. Trace and Rare Earth Elements

Analyses of trace elements carried out on 24 elements are represented on Table 2. These elements follow same trend of evolution like major elements. The compatible elements present a high affinity for Fe-Mg minerals, with occurrence of olivine, pyroxene, spinel and magnetite [5]. The SiO₂ for compatible elements show a negative correlation all along the magmatic differentiation process for Sr and Cr (Figure 6). Sr content decreases during magmatic differentiation from 846-1115ppm in basanite to 219-244ppm in rhyolite; V presents a linear correlation and moderately decreases and varies from 266-276ppm in basanite to 5ppm in rhyolite; Cr presents a positive correlation and varies from 180-490ppm in basanite to 6ppm in rhyolites. Looking at the incompatible element versus SiO_2 , it indicates positive correlation of Nb, Zr, and Rb with SiO_2 .

The REE and multi elements results are presented in Table 2. The spectra of REE is normalised to Chondrite [20] (Figure 7). On the pattern, there is the enrichment of LREE (La, Ce, Nd, Sm) compared to the HREE (Gd, Dy, Er, Yb).

The multi-element spectra for the Wainama West lava represent a strong negative anomaly of Eu, Ba, and Sr and a positive anomaly of Nb, Ta, La, Zr, Hf, in both the trachytes and basanite (Figure 8). The trough at Sr is probably a consequence of low pressure plagioclase fractionation.

Table 2. Selected Trace elements (concentration in ppm) for Wainama West lava

	Basanite											
SAMPLE	W17	W18	W19	W20	W21	W22	W25	W26	W27	W28	W29	W30
Ba	469	460	482	488	465	480	479	472	471	471	469	471
Ce	90.5	90	91.7	89.2	90.2	90.1	90.4	90.2	89.7	91.2	90.3	89.8
Cr	420	430	410	420	428	420	420	420	420	452	420	490
Cs	0.28	0.25	0.24	0.31	0.24	0.29	0.27	0.18	0.21	0.2	0.23	0.19
Dy	5.76	5.66	5.48	5 77	5.60	5 71	5.20	5.4	5 71	57	5 57	5.68
Eu	3,70	2.16	2.06	2.15	2.1	2.08	2.05	2.16	2.06	2.06	2.09	2.1
Eu C-	3,07	3,10	3,00	20.9	20.0	2,90	2,95	21.0	3,00	3,00	2,90	21.1
Ga	23,1	22,4	22	20,8	20,9	21	21,2	21,9	21,2	21,2	21	21,1
Ga	7,85	7,94	7,83	8,06	8	8,08	8,18	7,74	1,13	8,06	7,69	8,04
Hf	5,5	5,5	5,7	5,5	5,5	5,5	5,6	5,5	5,3	5,7	5,5	5,6
Но	0,98	1,04	1	1,07	1	1,01	1,06	1,02	0,99	1,01	1,01	0,95
La	43,1	42,5	43,8	42,4	42,6	43	42,3	42,8	42,3	43,4	43,1	42,3
Lu	0,26	0,26	0,27	0,26	0,28	0,28	0,27	0,27	0,26	0,3	0,25	0,28
Nb	58,5	58,3	59,3	57,5	57,6	58,1	57,8	57,6	57,8	58,5	57,6	57,8
Nd	45,6	45,8	46	44,9	45,4	45,2	45,6	45,8	44,3	45,8	46.1	44,5
Rb	25,8	25,4	25,5	27	25,6	27,1	29,2	26,8	25,6	27	26,4	26,9
Sm	8,94	9,08	9,05	9,1	9,49	9,11	9,23	9,33	9	9,47	9,39	9,45
Sn	2	2	2	2	1	2	2	2	2	1	2	2
Sr	858	846	869	868	848	871	1030	1115	959	941	938	973
Та	3,5	3,4	3,5	3,4	3,3	3,3	3,4	3,4	3,4	3,4	3,4	3,4
Tb	1,12	1,06	1,13	1,13	1,16	1,09	1,11	1,11	1,1	1,14	1,09	1,1
Th	4,02	3,93	4,01	3,98	4,12	4,05	4	4	4,09	3,97	3,94	4
Tm	0,3	0.32	0,34	0,32	0,35	0,33	0,35	0,33	0,34	0,33	0,32	0.29
U	1.15	1.07	1.21	1.11	1.08	1.12	1.11	1.08	1.08	1.13	1.07	1.01
V	273	271	274	267	266	273	276	275	266	268	270	269
W	1	1	1	1	1	1	1	1	1	1	1	1
v	25.1	25.3	25.8	24.9	24.9	25.4	25.2	25.1	24.9	25.2	25.2	25.1
Yh	1 91	20,5	23,0	1 00	1 01	2.03	1 98	1 93	1 01	1.93	1 93	2.01
7r	2/3	2,01	2,1	240	230	2,05	230	241	230	2/3	241	2,01
Zı	243	240	240	240	239	242	239	241	239	243	241	240
				Troch	vto					Dhr	alita	
CAMDLE	11/22	W24	W25	Trach	yte	W20	XX71	11/2	W/2	Rhy	olite	WC
SAMPLE	W33	W34	W35	Trach W36	wte W37	W38	W1	W2	W3	Rhy W4	w5	W6
SAMPLE Ba	W33 185,5	W34 213	W35 160,5	Trach W36 209	wite W37 223	W38 157,5	W1 738	W2 721	W3 687	Rhy W4 717	olite W5 699	W6 723
SAMPLE Ba Ce	W33 185,5 404	W34 213 359	W35 160,5 381	Trach W36 209 399	w37 223 396	W38 157,5 367	W1 738 248	W2 721 275	W3 687 273	Rhy W4 717 288	olite W5 699 318	W6 723 259
SAMPLE Ba Ce Cr	W33 185,5 404 10	W34 213 359 12	W35 160,5 381 10	Trach W36 209 399 220	yte W37 223 396 10	W38 157,5 367 11	W1 738 248 13	W2 721 275 10	W3 687 273 10	Rhy W4 717 288 11	olite W5 699 318 10	W6 723 259 12
SAMPLE Ba Ce Cr Cs	W33 185,5 404 10 0,12	W34 213 359 12 0,12	W35 160,5 381 10 0,15	Trach W36 209 399 220 0,12	yte W37 223 396 10 0,13	W38 157,5 367 11 0,14	W1 738 248 13 0,12	W2 721 275 10 0,14	W3 687 273 10 0,14	Rhy W4 717 288 11 0,15	olite W5 699 318 10 0,14	W6 723 259 12 0,14
SAMPLE Ba Ce Cr Cs Dy	W33 185,5 404 10 0,12 20,7	W34 213 359 12 0,12 18,1	W35 160,5 381 10 0,15 19,65	Trach W36 209 399 220 0,12 20,2	yte W37 223 396 10 0,13 20,4	W38 157,5 367 11 0,14 19,3	W1 738 248 13 0,12 13,8	W2 721 275 10 0,14 15,4	W3 687 273 10 0,14 19,75	Rhy W4 717 288 11 0,15 17,55	W5 699 318 10 0,14 19,45	W6 723 259 12 0,14 14,95
SAMPLE Ba Ce Cr Cs Dy Eu	W33 185,5 404 10 0,12 20,7 3,08	W34 213 359 12 0,12 18,1 2,65	W35 160,5 381 10 0,15 19,65 2,98	Trach W36 209 399 220 0,12 20,2 3,01	yte W37 223 396 10 0,13 20,4 3,14	W38 157,5 367 11 0,14 19,3 2,74	W1 738 248 13 0,12 13,8 3,82	W2 721 275 10 0,14 15,4 3,89	W3 687 273 10 0,14 19,75 4,25	Rhy W4 717 288 11 0,15 17,55 4,11	W5 699 318 10 0,14 19,45 4,15	W6 723 259 12 0,14 14,95 3,82
SAMPLE Ba Ce Cr Cs Dy Eu Ga	W33 185,5 404 10 0,12 20,7 3,08 41,3	W34 213 359 12 0,12 18,1 2,65 42,8	W35 160,5 381 10 0,15 19,65 2,98 42	Trach W36 209 399 220 0,12 20,2 3,01 42	yte W37 223 396 10 0,13 20,4 3,14 42,9	W38 157,5 367 11 0,14 19,3 2,74 42	W1 738 248 13 0,12 13,8 3,82 37,5	W2 721 275 10 0,14 15,4 3,89 37,9	W3 687 273 10 0,14 19,75 4,25 37,1	Rhy W4 717 288 11 0,15 17,55 4,11 37,9	W5 699 318 10 0,14 19,45 4,15 37,8	W6 723 259 12 0,14 14,95 3,82 36,9
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3	W34 213 359 12 0,12 18,1 2,65 42,8 20	W35 160,5 381 10 0,15 19,65 2,98 42 22,2	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1	W38 157,5 367 11 0,14 19,3 2,74 42 20	W1 738 248 13 0,12 13,8 3,82 37,5 15,6	W2 721 275 10 0,14 15,4 3,89 37,9 17,45	W3 687 273 10 0,14 19,75 4,25 37,1 20,3	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2	W5 699 318 10 0,14 19,45 4,15 37,8 23,6	W6 723 259 12 0,14 14,95 3,82 36,9 16,75
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5
SAMPLE Ba Ce Cr Cs Dy Eu Ga Ga Gd Hf Ho La Lu	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La Lu Nb	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45 267	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La Lu Nb Nd	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45 267 156,5	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270 136	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270 151,5	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261 156,5	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270 154,5	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266 141	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181 102	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183 113	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188 122,5	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185 124,5	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187 142	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178 107
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La Lu Nb Nd Rb	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45 267 156,5 114	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270 136 115	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270 151,5 116	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261 156,5 113,5	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270 154,5 116,5	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266 141 114,5	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181 102 93	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183 113 93,5	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188 122,5 93,7	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185 124,5 91,8	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187 142 93,5	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178 107 92
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La Lu Nb Nd Rb Sm	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45 267 156,5 114 28,3	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270 136 115 24,5	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270 151,5 116 27,6	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261 156,5 113,5 27,7	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270 154,5 116,5 27,8	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266 141 114,5 26,6	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181 102 93 18,8	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183 113 93,5 20,8	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188 122,5 93,7 23,6	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185 124,5 91,8 21,7	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187 142 93,5 25	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178 107 92 19
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La Lu Nb Nd Rb Sm Sn	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45 267 156,5 114 28,3 11	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270 136 115 24,5 10	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270 151,5 116 27,6 10	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261 156,5 113,5 27,7 10	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270 154,5 116,5 27,8 11	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266 141 114,5 26,6 11	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181 102 93 18,8 8	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183 113 93,5 20,8 7	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188 122,5 93,7 23,6 7	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185 124,5 91,8 21,7 7	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187 142 93,5 25 7	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178 107 92 19 7
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La Lu Nb Nd Rb Sm Sn Sr	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45 267 156,5 114 28,3 11 23,9	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270 136 115 24,5 10 28,8	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270 151,5 116 27,6 10 20,8	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261 156,5 113,5 27,7 10 21,8	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270 154,5 116,5 27,8 11 24	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266 141 114,5 26,6 11 23,8	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181 102 93 18,8 8 242	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183 113 93,5 20,8 7 236	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188 122,5 93,7 23,6 7 219	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185 124,5 91,8 21,7 7 239	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187 142 93,5 25 7 223	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178 107 92 19 7 244
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La Lu Nb Nd Rb Sm Sn Sr Ta	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45 267 156,5 114 28,3 11 23,9 15,5	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270 136 115 24,5 10 28,8 15,7	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270 151,5 116 27,6 10 20,8 15,5	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261 156,5 113,5 27,7 10 21,8 15,2	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270 154,5 116,5 27,8 11 24 15,6	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266 141 114,5 26,6 11 23,8 15,5	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181 102 93 18,8 8 242 11,2	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183 113 93,5 20,8 7 236 11,6	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188 122,5 93,7 23,6 7 219 11,2	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185 124,5 91,8 21,7 7 239 11,2	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187 142 93,5 25 7 223 11,3	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178 107 92 19 7 244 11,2
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La Lu Nb Nd Rb Sm Sn Sr Ta Ta Tb	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45 267 156,5 114 28,3 11 23,9 15,5 3,68	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270 136 115 24,5 10 28,8 15,7 3,2	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270 151,5 116 27,6 10 20,8 15,5 3,58	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261 156,5 113,5 27,7 10 21,8 15,2 3,58	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270 154,5 116,5 27,8 11 24 15,6 3,72	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266 141 114,5 26,6 11 23,8 15,5 3,39	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181 102 93 18,8 8 242 11,2 2,39	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183 113 93,5 20,8 7 236 11,6 2,75	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188 122,5 93,7 23,6 7 219 11,2 3,43	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185 124,5 91,8 21,7 7 239 11,2 3,02	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187 142 93,5 25 7 223 11,3 3,57	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178 107 92 19 7 244 11,2 2,7
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La Lu Nb Nd Rb Sm Sn Sr Ta Tb Tb	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45 267 156,5 114 28,3 11 23,9 15,5 3,68 23,4	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270 136 115 24,5 10 28,8 15,7 3,2 23,4	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270 151,5 116 27,6 10 20,8 15,5 3,58 23,3 23,3	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261 156,5 113,5 27,7 10 21,8 15,2 3,58 23,1	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270 154,5 116,5 27,8 11 24 15,6 3,72 23,2	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266 141 114,5 26,6 11 23,8 15,5 3,39 23,2	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181 102 93 18,8 8 242 11,2 2,39 16 35	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183 113 93,5 20,8 7 236 11,6 2,75 16.8	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188 122,5 93,7 23,6 7 219 11,2 3,43 16 55	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185 124,5 91,8 21,7 7 239 11,2 3,02 16 25	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187 142 93,5 25 7 223 11,3 3,57 15,7	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178 107 92 19 7 244 11,2 2,7 16
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La Lu Nb Nd Rb Sm Sn Sr Ta Tb Th	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45 267 156,5 114 28,3 11 23,9 15,5 3,68 23,4 159	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270 136 115 24,5 10 28,8 15,7 3,2 23,4 1,43	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270 151,5 116 27,6 10 20,8 15,5 3,58 23,3 1,58	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261 156,5 113,5 27,7 10 21,8 15,2 3,58 23,1 1,55	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270 154,5 116,5 27,8 11 24 15,6 3,72 23,2 1,55	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266 141 114,5 26,6 11 23,8 15,5 3,39 23,2 1,48	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181 102 93 18,8 8 242 11,2 2,39 16,35 1,08	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183 113 93,5 20,8 7 236 11,6 2,75 16,8 1 19	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188 122,5 93,7 23,6 7 219 11,2 3,43 16,55 1,52	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185 124,5 91,8 21,7 7 239 11,2 3,02 16,25 1,29	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187 142 93,5 25 7 223 11,3 3,57 15,7 1,46	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178 107 92 19 7 244 11,2 2,7 16,1 107
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La Lu Nb Nd Rb Sm Sn Sr Ta Tb Th Th Th	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45 267 156,5 114 28,3 11 23,9 15,5 3,68 23,4 1,59 5 88	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270 136 115 24,5 10 28,8 15,7 3,2 23,4 1,43 5,44	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270 151,5 116 27,6 10 20,8 15,5 3,58 23,3 1,58 6,16	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261 156,5 113,5 27,7 10 21,8 15,2 3,58 23,1 1,55 6.02	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270 154,5 116,5 27,8 11 24 15,6 3,72 23,2 1,55 6,31	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266 141 114,5 26,6 11 23,8 15,5 3,39 23,2 1,48 5,83	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181 102 93 18,8 8 242 11,2 2,39 16,35 1,08 4,05	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183 113 93,5 20,8 7 236 11,6 2,75 16,8 1,19 4,42	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188 122,5 93,7 23,6 7 219 11,2 3,43 16,55 1,52 4,25	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185 124,5 91,8 21,7 7 239 11,2 3,02 16,25 1,29 4,56	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187 142 93,5 25 7 223 11,3 3,57 15,7 1,46	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178 107 92 19 7 244 11,2 2,7 16,1 1,07 4,14
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La Lu Nb Nd Rb Sm Sn Sr Ta Tb Th Th Tm U	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45 267 156,5 114 28,3 11 23,9 15,5 3,68 23,4 1,59 5,88	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270 136 115 24,5 10 28,8 15,7 3,2 23,4 1,43 5,44 5	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270 151,5 116 27,6 10 20,8 15,5 3,58 23,3 1,58 6,16 5	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261 156,5 113,5 27,7 10 21,8 15,2 3,58 23,1 1,55 6,02 5	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270 154,5 116,5 27,8 11 24 15,6 3,72 23,2 1,55 6,31 5	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266 141 114,5 26,6 11 23,8 15,5 3,39 23,2 1,48 5,83 5	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181 102 93 18,8 8 242 11,2 2,39 16,35 1,08 4,05 5	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183 113 93,5 20,8 7 236 11,6 2,75 16,8 1,19 4,42	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188 122,5 93,7 23,6 7 219 11,2 3,43 16,55 1,52 4,25 5	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185 124,5 91,8 21,7 7 239 11,2 3,02 16,25 1,29 4,56	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187 142 93,5 25 7 223 11,3 3,57 15,7 1,46 4,59	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178 107 92 19 7 244 11,2 2,7 16,1 1,07 4,14
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La Lu Nb Nd Rb Sm Sn Sr Ta Tb Th Th Th Tm U V W	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45 267 156,5 114 28,3 11 23,9 15,5 3,68 23,4 1,59 5,88 5 <td>W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270 136 115 24,5 10 28,8 15,7 3,2 23,4 1,43 5,44 5</td> <td>W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270 151,5 116 27,6 10 20,8 15,5 3,58 23,3 1,58 6,16 5 2</td> <td>Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261 156,5 113,5 27,7 10 21,8 15,2 3,58 23,1 1,55 6,02 5 2</td> <td>yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270 154,5 116,5 27,8 11 24 15,6 3,72 23,2 1,55 6,31 5</td> <td>W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266 141 114,5 26,6 11 23,8 15,5 3,39 23,2 1,48 5,83 5</td> <td>W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181 102 93 18,8 8 242 11,2 2,39 16,35 1,08 4,05 5 2</td> <td>W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183 113 93,5 20,8 7 236 11,6 2,75 16,8 1,19 4,42 5 2</td> <td>W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188 122,5 93,7 23,6 7 219 11,2 3,43 16,55 1,52 4,25 5 2</td> <td>Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185 124,5 91,8 21,7 7 239 11,2 3,02 16,25 1,29 4,56 5 2</td> <td>W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187 142 93,5 25 7 223 11,3 3,57 15,7 1,46 4,59 5 2</td> <td>W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178 107 92 19 7 244 11,2 2,7 16,1 1,007 4,14 5</td>	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270 136 115 24,5 10 28,8 15,7 3,2 23,4 1,43 5,44 5	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270 151,5 116 27,6 10 20,8 15,5 3,58 23,3 1,58 6,16 5 2	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261 156,5 113,5 27,7 10 21,8 15,2 3,58 23,1 1,55 6,02 5 2	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270 154,5 116,5 27,8 11 24 15,6 3,72 23,2 1,55 6,31 5	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266 141 114,5 26,6 11 23,8 15,5 3,39 23,2 1,48 5,83 5	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181 102 93 18,8 8 242 11,2 2,39 16,35 1,08 4,05 5 2	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183 113 93,5 20,8 7 236 11,6 2,75 16,8 1,19 4,42 5 2	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188 122,5 93,7 23,6 7 219 11,2 3,43 16,55 1,52 4,25 5 2	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185 124,5 91,8 21,7 7 239 11,2 3,02 16,25 1,29 4,56 5 2	W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187 142 93,5 25 7 223 11,3 3,57 15,7 1,46 4,59 5 2	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178 107 92 19 7 244 11,2 2,7 16,1 1,007 4,14 5
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La Lu Nb Nd Rb Sm Sn Sr Ta Tb Th Th Tm U V V W	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45 267 156,5 114 28,3 11 23,9 15,5 3,68 23,4 1,59 5,88 5 1 10,5	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270 136 115 24,5 10 28,8 15,7 3,2 23,4 1,43 5,44 5 2 80.1	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270 151,5 116 27,6 10 20,8 15,5 3,58 23,3 1,58 6,16 5 2 102	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261 156,5 113,5 27,7 10 21,8 15,2 3,58 23,1 1,55 6,02 5 2 101,5 5 2 101,5 5 101,5 105,5 105,5 105,5 105,5 105,5 113,5 27,7 10 21,8 15,2 3,58 23,11 1,55 6,02 5 2 101,5 2 101,5 2 105,5 105,5 105,5 105,5 105,5 105,5 105,5 105,5 105,5 105,5 113,5 27,7 10 21,8 15,5 2,7,7 10 21,8 25,5 20,7 20	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270 154,5 116,5 27,8 11 24 15,6 3,72 23,2 1,55 6,31 5 1 104	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266 141 114,5 26,6 11 23,8 15,5 3,39 23,2 1,48 5,83 5 1 04,5	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181 102 93 18,8 8 242 11,2 2,39 16,35 1,08 4,05 5 3 75 6	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183 113 93,5 20,8 7 236 11,6 2,75 16,8 1,19 4,42 5 3	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188 122,5 93,7 23,6 7 219 11,2 3,43 16,55 1,52 4,25 5 3 08,7 20,	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185 124,5 91,8 21,7 7 239 11,2 3,02 16,25 1,29 4,56 5 3 102	with W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187 142 93,5 25 7 223 11,3 3,57 15,7 1,46 4,59 5 3 110	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178 107 92 19 7 244 11,2 2,7 16,1 1,007 4,14 5 3 00
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La Lu Nb Nd Rb Sm Sn Sr Ta Tb Th Th Tm U V V W Y	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45 267 156,5 114 28,3 11 23,9 15,5 3,68 23,4 1,59 5,88 5 1 101,5	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270 136 115 24,5 10 28,8 15,7 3,2 23,4 1,43 5,44 5 2 89,1 2,62	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270 151,5 116 27,6 10 20,8 15,5 3,58 23,3 1,58 6,16 5 2 102 0,55 2,55 102 0,55 102 0,55 102 0,55 102 0,55 105 105 105 105 105 105 105 1	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261 156,5 113,5 27,7 10 21,8 15,2 3,58 23,1 1,55 6,02 5 2 101,5 2	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270 154,5 116,5 27,8 11 24 15,6 3,72 23,2 1,55 6,31 5 1 104 104	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266 141 114,5 26,6 11 23,8 15,5 3,39 23,2 1,48 5,83 5 1 94,5 2,52 1	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181 102 93 18,8 8 242 11,2 2,39 16,35 1,08 4,05 5 3 75,6	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183 113 93,5 20,8 7 236 11,6 2,75 16,8 1,19 4,42 5 3 81,3 20,20	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188 122,5 93,7 23,6 7 219 11,2 3,43 16,55 1,52 4,25 5 3 98,7 0,52	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185 124,5 91,8 21,7 7 239 11,2 3,02 16,25 1,29 4,56 5 3 103	with W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187 142 93,5 25 7 223 11,3 3,57 15,7 1,46 4,59 5 3 119	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178 107 92 19 7 244 11,2 2,7 16,1 1,07 4,14 5 3 90
SAMPLE Ba Ce Cr Cs Dy Eu Ga Gd Hf Ho La Lu Nb Nd Rb Sm Sn Sr Ta Tb Th Th Th Tm U V W Y Yb	W33 185,5 404 10 0,12 20,7 3,08 41,3 23,3 35,3 4,07 204 1,45 267 156,5 114 28,3 11 23,9 15,5 3,68 23,4 1,59 5,88 5 1 101,5 10,35	W34 213 359 12 0,12 18,1 2,65 42,8 20 35,6 3,45 175 1,36 270 136 115 24,5 10 28,8 15,7 3,2 23,4 1,43 5,44 5 2 89,1 8,89	W35 160,5 381 10 0,15 19,65 2,98 42 22,2 35,3 3,96 191,5 1,45 270 151,5 116 27,6 10 20,8 15,5 3,58 23,3 1,58 6,16 5 2 102 9,72	Trach W36 209 399 220 0,12 20,2 3,01 42 22,4 34,7 3,95 198,5 1,49 261 156,5 113,5 27,7 10 21,8 15,2 3,58 23,1 1,55 6,02 5 2 101,5 9,9	yte W37 223 396 10 0,13 20,4 3,14 42,9 22,1 35,5 4,01 204 1,46 270 154,5 116,5 27,8 11 24 15,6 3,72 23,2 1,55 6,31 5 1 104 10,15	W38 157,5 367 11 0,14 19,3 2,74 42 20 35,2 3,74 179 1,42 266 141 114,5 26,6 11 23,8 15,5 3,39 23,2 1,48 5,83 5 1 94,5 9,58	W1 738 248 13 0,12 13,8 3,82 37,5 15,6 24,6 2,81 125 1,02 181 102 93 18,8 8 242 11,2 2,39 16,35 1,08 4,05 5 3 75,6 6,95	W2 721 275 10 0,14 15,4 3,89 37,9 17,45 24,3 3,07 144 1,15 183 113 93,5 20,8 7 236 11,6 2,75 16,8 1,19 4,42 5 3 81,3 7,69	W3 687 273 10 0,14 19,75 4,25 37,1 20,3 25,1 3,92 151 1,46 188 122,5 93,7 23,6 7 219 11,2 3,43 16,55 1,52 4,25 5 3 98,7 9,89	Rhy W4 717 288 11 0,15 17,55 4,11 37,9 20,2 24,7 3,43 164 1,13 185 124,5 91,8 21,7 7 239 11,2 3,02 16,25 1,29 4,56 5 3 103 7,95	with W5 699 318 10 0,14 19,45 4,15 37,8 23,6 24,4 3,97 197 1,26 187 142 93,5 25 7 223 11,3 3,57 15,7 1,46 4,59 5 3 119 8,39	W6 723 259 12 0,14 14,95 3,82 36,9 16,75 25,1 2,92 137,5 1,02 178 107 92 19 7 244 11,2 2,7 16,1 1,07 4,14 5 3 90 7,14



Figure 6. Binary diagrams for some compatible and incompatible elements against SiO₂. Symbols as for the Figure 5



Figure 7. REE spectra of the Wainama West lava normalised with Chondrite [20]. Symbols as for the Figure 5 (OIB= Ocean Island Basalt, N-MORB= normalised-mid ocean ridge basalt, E-MORB= enriched-mid ocean ridge basalt



Figure 8. Primitive mantle normalised spider diagram of trace elements of the Wainama West lava [35]. Symbols as for the Figure 5

5. Interpretation and Discussion

5.1. Magma Generation

The major and trace elements distribution shows that the dominant process for the generation of rhyolitic and trachytic lavas from the basanite parental melt is fractional crystallisation. The fractionating phases are olivine, clinopyroxene, plagioclase (Figure 9), ferro-titano oxide and apatite as indicated by a continuous decrease in CaO, Fe₂O₃, TiO₂, P₂O₅, MgO, with a corresponding increase in Al₂O₃, Na₂O, K₂O (Figure 10). A binary diagram of the oxides against SiO₂ indicates a decrease in MgO and is interpreted as a continuous fractionation of olivine from basanite through trachyte to rhyolite. A decrease in CaO indicates fractionation of clinopyroxene. Petrographically, basanite contain more pyroxene than trachyte and rhyolite, which is an evidence of differentiation through fractional crystallization. The dispersion of Fe₂O₃, TiO₂, V and P₂O₅ is clear in all petrographic types and explains fractionation of ferrotitano-oxide and apatite. The content of K₂O, Na₂O, and Al₂O₃ shows a lesser evolution which is very different. This is explained by non-crystallisation of alkaline feldspars in the mafic rocks. The study of trace elements shows that olivine and clinopyroxene preferentially incorporates Co and Ni, ferro-titano oxide fractionate V, apatite fractionates intermediary elements like Y, Co, Ni, the plagioclases fractionate Sr, Ba, Eu and to a lesser degree La.



Figure 9. Sr vs Ba diagram for Wainama West lava; fractionation and assimilation shown after [10] modified. Symbols as for the Figure 5



Figure 10. Zr/Nb diagram of Wainama West lavas. Dashed lines show fields of rocks of Meidob Hills, sudan (after [10] modified) indicating a mantle source of mafic rocks (1) or assimilation for rhyolite; the trend of fractionation is outlined (3). Symbols as for the Figure 5

These results permit us to interpret the principal variations in trace elements. The first evolutionary series is marked by a decrease in transition elements fractionated by olivine and clinopyroxene (Sr, Cr,) and after V to separate the ferro-titano oxide. The rest of the other elements have an incompatible behaviour. A decrease in the concentration of Eu and Sr in trachyte is due to fractionation of plagioclase (Figure 8). Generally, in the lava studied, we observe enrichment in LREE as compared to HREE. This suggests presence of residual garnet in the source during partial melting. An evidence that the rocks are coming from processes of fractional crystallisation. Removal of feldspar from a felsic rock (rhyolite) by crystal fractionation or the partial melting of a rock in which feldspar is retained in the source will give rise to a negative anomaly in the melt. Generally, multielement spectra have negative anomalies in Ba, Eu, and Sr, in trachyte and rhyolite suggesting fractionation of plagioclases and positive anomalies in, Nb, La, Zr and Dy.

5.2. Mantle Source Characteristic

The Dy/Yb versus La/Yb diagram (Figure 11) indicates the melting of garnet and spinel peridotite based on the compatibility of Yb and incompatibility of La in garnet and different rate and fraction of La/Yb and Dy/Yb ratios during the melting stages in the garnet stability field. The study of the discrimination diagram between melting of garnet and spinel peridotite shows that the basanitic magma of the Wainama West area is formed from the partial melting of garnet peridotite. The trend of the basanitic lava of this area falls within the high degrees (11-12%) of partial melting of a garnet rich peridotite compared to the low degree partial melting of Mount Cameroon (8-10%), but and both fall mainly around the 2% partial melting curve [27,38].



Figure 11. The Dy/Yb vs La/Yb diagram. Melt curves for garnet peridotite and spinel peridotite are from [3]. Mount Bambouto from Nkouathio (2006), Mount Bamenda from [16], Mount Cameroun from [34]. Symbols as for the Figure 5

5.3. Contamination and Assimilation Plots

The Zr/Nb diagram indicates assimilation for benmoreitic trachyte pumice and lava, [10] (Figure 10). The lava of Wainama West has high Ba concentrations in rhyolite and trachyte with exceptions in samples W33 (185.5ppm) and W35 (160.5ppm) and low Sr concentrations decreasing from the rhyolite to basalt. This is explained by the partial assimilation of the magma by the country rocks. The fractionation of olivine and pyroxene clearly increases Sr and Ba content of the residual liquid. The Zr\Nb Vs Zr diagram (Figure 10) argues for more assimilation in rhyolite which has a high Zr\Nb ratio of 6.4 and 6.0 for Zr content range of 1125 and 1145ppm. In contrast, the trachyte samples display considerably higher Zr values of 1570 and 1610ppm, clearly indicating a fractional process.



Figure 12. The Ta/Yb vs Th/Yb diagram. Symbols as for the Figure 5



Figure 13. Zr/Nb vs La/Nb diagram of Wainama West area. Comparison with major reservoirs (OIB) oceanic island basalts; (MORB) mid-oceanic ridge basalts; (PM) primitive mantle; mantle poles HIMU (high ²³⁸U/²⁰⁴Pb ratio), EMI and EMII (enriched); (EMI) enriched mantle I, (EMII) enriched mantle II. (CC) continental crust The data (MORB, PM, C.C, HIMU, EMI, EMII) are from Weaver (1991). Symbols as for the Figure 5

5.4. Petrogenesis

Several authors have shown a similarity between multi-element spectra of lava along the CVL ([9,13-22]). This similarity is equally observed in the Wainama West area. In effect lava of this area show spectra enriched in LREE and in incompatible elements. The REE and Trace elements spectra of this area, as well as that along the CVL, are similar in the OIB spectra. The ratio of trace incompatible elements compared to others of the CVL shows that it presents an OIB signature (Figure 12) with variable participation of HIMU components (Figure 13). However, the Zr/Hf and Nb/Ta ratio diagram (Figure 14) shows that the Wainama West mantle source is similar to those of the continental basalts, OIB, OVG and the Kenva rift. The elemental ratios like Nb/Ta and Zr/Hf have been very useful in finger printing the source of the volcanic rocks of the study area. The Zr/Hf ratios of the study area have values similar to those of the OIBs, whereas Nb/Ta ratios tend to be higher. The Zr/Hf ratio ranges from 42.7 to 47.1 with an average of 44.9 and the Nb/Ta ratio range from 16.5 to 17.6 with an average of 17.05. The above values are respectively above and in the range of the OIB. (OIB: Nb/Ta=15.9- 0.6, Zr/Hf =35.5-45.5) [28]. This indicates a slight Nb excess in basanite but assuming similar degree of partial melting. However, the Nb/Ta ratio is slightly higher than the range obtained for the continental part of the CVL (Nb/Ta=11.19-14.77) ([15,23,27,36]) but it is within the Tibesti volcano range (Nb/Ta=11.19-17.49) [12], Oku volcanic group and Kenya rift. Finally, [39] used the slightly higher Nb/Ta and average Zr/Hf ratio as evidence of derivation from distinct liquid relative to the others although sharing a common source region. This difference is only controlled by fractional crystallization.



Figure 14. Zr/Hf vs. Nb/Ta diagram. PM, N-MORB, EMORB, and OIB from [35]; chondritic values from [21]; MORB, OIB, and continental basalts fields after [28]; Kenya rift field drawn with the data of [31,32] and [29], Mount Manengouba from [30], Mount Bamenda from [16].

5.5. Geotectonic Context

The combined study of the petrology and geochemistry reveal that the lava of Wainama West area is of the within plate volcanic setting. From the Ta/Yb vs Th/Ta plot, the rocks samples fall in the Within Plate Basalt (WPB) (Figure 15A). The Ta/Hf vs Th/Hf plot indicates the rock samples fall in the Within Plate Volcanin Zone (WPVZ) (Figure 15B).

5.6. Comparing the Wainama West Lava and others along the CVL

The general volcanic situation and the chemical composition of the lavas of the study area are similar to others along the CVL. Wainama West lava fall within the alkaline series which is concordant to those of the volcanic massif of Adamawa, Mount Cameroon which constitutes a weakly alkaline series [37], those of Tombel graben are mildly alkaline [27], Mount Manengouba belongs to the sodic alkaline series [30], Mount Bamenda also has an alkaline affinity [16] and Mount Oku [25]. This confirms the fact that majority of the rocks along the CVL are alkaline in nature.

The lava of Wainama West, Mount Bamenda, Mount Oku and Mount Cameroon has the same origin (mantle source). Comparing the source of the volcanic rocks of Wainama West and that of the OIB and MORB, the source has the same origin as that of the OIB (Figure 12, Figure 13). The Zr/Hf ratio average falls within the range of OIB while Nb/Ta ratio is slightly higher than the OIB parts of the CVL but is within the Tibesti volcano, Oku volcanic group, and Kenya rift.



Figure 15. Diagrams showing the geotectonic context of the Wainama West lava (A) Ta/Yb vs Th/Ta plot, (B) Ta/Hf vs Th/Hf plot [33]. Symbols as for the Figure 5

6. Conclusion

Rocks and lava of the Wainama West area are made up of basanite, trachyte and rhyolite. This volcanic series is strongly differentiated and evolves from alkali basalts to rhyolites with a Daly gap. Their geochemical behaviour show an enrichment in SiO₂, Al₂O₃, Na₂O, K₂O and an impoverishment in MgO and CaO. A good correlation exists between some minor elements (U, Nb, Ta, La, Zr, Hf, Yb, Rb, Y) with that of DI. The principal differentiation mechanism of the Wainama West lava is fractional crystallisation, marked by a progressive decrease in MgO and CaO content and an increase in Na₂O and K₂O content. The principal phases that fractionate are ferro-titano oxide, olivine, clinopyroxene and plagioclases, with fractionation of olivine and clinopyroxene appearing at the beginning of the differentiation. Eu and Sr indicate a negative anomaly in trachyte and rhyolite. The negative anomaly of Eu and Sr in trachyte and rhyolite indicates plagioclase fractionation. The lavas of the Wainama area are of the alkaline series, originate from the mantle and has same source as those of the OIB with HIMU signatures. The geodynamic context of the lavas of the Wainama West fall within plate volcanic setting, Within Plate Basalt (WPB) and Within Plate Volcanic Zone (WPVZ).

Acknowledgments

The authors wish to thank the anonymous reviewers for the comments and suggestions that permitted a substantial enhancement of the original manuscript.

References

 Asaah, A. V., Zoheir, B., Lehmann, B., Frei, D., Burgess, R., and Suh, C. E., 2015. *Geochemistry and geochronology of the ~620 My gold-associated Batouri granitoids, Cameroon*. International Geology Review, v. 57, p. 1485-1509.

- [2] Atouba O. C.L., Chazot G., Moundi A., Agranier A., Bellon H., Nonnotte P., Nzenti J. P., Kankeu B., 2015. *Mantle sources* beneath the Cameroon Volcanic Line: geochemistry and geochronology of the Bamoun plateau mafic rocks. Arab. J. Geosci (2016) 9:270.
- [3] Bogaard, P.J.F, Wörner, G., 2003. Petrogenesis of basanitic to tholeiitic volcanic rocks from theMiocene Vogelsberg, Central Germany. J. Petrol. 44 (2003) 569-602.
- [4] Burke, K., 2001. Origin of the Cameroon Line of volcano-capped swells. J. Geol. 109, 349-362.
- [5] Cox, K. G., Bell, J. D., Pankhurst, R. J., 1987. *The interpretation of igneous rocks*. Georges Allen and Unwin London, p450.
- [6] Deruelle, B., Ezangono J., Lissom J., Loule E., Ngnotue N., Ngounouno I., Nkoumbou C., 1987. *Mio-Pliocene basaltic lava flows and phonolitic and trachytic plugs north and east of Ngaoundéré (Adamawa, Cameroon)*. In: C., Matheis A., Schandelmeier (Eds), Current Research in African Earth Sciences, Balkema, Rotterdam, 261-264.
- [7] Deruelle, B., Moreau, C., Nkoumbou, C., Kambou, R., Lissom, J., Njonfang, E., Ghogumu, R. T., Nono, A., 1991. The Cameroon Line: a review. In Kampunzu, A. B., and Lubala, R. T., eds. Magmatism in extension structure settings: the Phanerozoic African Plate. Berlin, Springer, p 275-327.
- [8] Déruelle, B., Ngounouno, I., Demaiffe, D., 2007. The "Cameroon Hot Line" (CHL): a unique example of active alkaline intraplate structure in both oceanic and continental lithospheres. C. R. Geoscience 339, p589-600.
- [9] Fitton, J. G., 1987. The Cameroun Line, West Africa; a comparison between oceanic and continental alkaline volcanism. G. and Upton, B.G.J. (eds), Alkaline igneous rocks. Geological Society of London Special Publication 30, 273-291.
- [10] Franz, G., Steiner, G., Volker, F., Pudlo, D., hammerschmidt, K., 1999. Plume related alkaline magmatism in Central Africa- the Meidob hills (W Sudan). Chem. Geol. 157, 27-47.
- [11] Geze, B., 1953. Les volcans du Cameroun occidental. Bulletin of Volcanology 13, 63-92.
- [12] Gourgaud A., Vincent P.M., 2004. Petrology of two continental alkaline intraplate series at Emi Koussi volcano, Tibesti, Chad. J Volcanol Geotherm Res 129:261-290.
- [13] Halliday, A.N., Dickin, A.P., Fallick, A.E., Fitton, J.G., 1988. Mantle dynamics: a Nd, Sr, Pb and O isotopics study of the Cameroon line volcanic chain. J. Petrol. 29, 181-211.
- [14] Irvine, T.N., Baragar, W.R.A., 1971. A guide to chemical classification of the common volcanic rocks. Canadian journal of Earth Sciences 8, 523-548.
- [15] Kamgang, P., Njonfang, E., Nono, A., Gountie, D., Tchoua, F., 2010. Petrogenesis of a silicic magma system: Geochemical evidence from Bamenda Mountains, NW Cameroon, Cameroon Volcanic Line. 341, 12, p645-654.

- [16] Kamgang, P., Chazot, G., Njonfang, E., Ngongang, N. B., Tchoua, F., 2013. Mantle sources and magma evolution beneath the Cameroon Volcanic Line: geochemistry of mafic rocks from the Bamenda Mountains (NW Cameroon). *Gondwana Res.* 24, p727-741.
- [17] Kampunzu, A.B., Popoff, M., 1991. Distribution of the main Phanerozoic African rifts and associated magmatism, introductory notes. In: Kampunzu, A.B., Lubala, R.(Eds.), Magmatism in Extensional Structural Settings. The Phanerozoic African Plate. Springer, Berlin, New York, Heidelberg, pp. 2-10.
- [18] Le Maitre, R. W., 2002. Igneous rocks: A classification and glossary of terms, second edition, Cambridge press.
- [19] Marzoli, A., Renne, P. R., Peccirillo, E. M., Castorina, F., Bellieni, G., Melfi, A. G., Nyobe, J. B., N'ni, J., 1999. Silicic magmas from the continental Cameroon Volcanic Line (Oku, Bambouto and Ngaoundéré): 40Ar–39Ar dates, petrology, Sr–Nd–O isotopes and their petrogenetic significance. Contrib. Mineral. Petrol. 135, 133-150.
- [20] McDonough, W.F., and Sun, S.S., 1995. The composition of the earth. Chem. Geol. 120, 223-253.
- [21] Münker, C., Pfänder, J. A., Weyer, S., Büchl, A., Kleine, T., Mezger, K., 2003. Evolution of planetary cores and the Earth– Moon system from Nb/Ta systematics. Science 301, 84-87.
- [22] Ngounouno, I., 1998. Chronologie, Pétrologie et cadre géodynamique du magmatisme cénozoïque de la Ligne duCameroun. In: Geosc. Au Cameroun, Ed., collect. Géocam, 1/1998, Press of University of Yaounde I, 169-184.
- [23] Ngounouno, I., Deruelle, B., Demaiffe, D., 2000. Petrology of the bimodal Cenozoic volcanism of the Kapsiki plateau (northernmost Cameroon, Central Africa). Journal of Volcanology and Geothermal Research 102, p21-44.
- [24] Njilah, I. K., 1991. Geochemistry and petrogenesis of Tertiary-Quaternary volcanic rocks from Oku-Ndu area, N.W. Cameroon. Ph.D. Thesis, University of Leeds.
- [25] Njilah, K., Temdjim, R., Nzolang, C., Tchuitchou, R., Ajonina, H., 2007. Geochemistry of Tertiary–Quaternary lavas of Mount. Oku, North-West Cameroon. Rev. Fac. Ing. Univ. Antioquia 40, p59-75 (Junior).
- [26] Njilah, K., moundi, A., Temdjim, R., Ntieche, B., 2013. Sr-Nd-Pd istopic studies of lavas from mount Oku volcano, North-west Cameroon: A case involving HIMU, depleted, and enriched mantle sources. Journal of Geology and Mining Research, vol. 5(5), pp.124-135.
- [27] Nkouathio, D. G., Kagou D. A., Bardintzeff, J. M., Wandji, P., Bellon H, Pouclet A., 2008. Evolution of volcanism in graben and horst along the Cenozoic Cameroon Line (Africa): implication for tectonic evolution and mantle source composition. Mineralogy and Petrology 94(3-4), p287-303.
- [28] Pfänder, J. A., Münker, C., Stracke, A., Mezger, K., 2007. Nb/Ta

and Zr/Hf in ocean island basalts – implications for crust-mantle differentiation and the fate of niobium. Earth Planet. Sci. Lett. 254, 158-172.

- [29] Platz, T., Foley, S. F., André, L., 2004. Low-pressure fractionation of the Nyiragongo volcanic rocks, Virunga Province, D.R. Congo. J. Volcanol. Geotherm. Res. 136, 269-295.
- [30] Pouclet, A., Kagou, D. A., Bardintzeff, J. M., Wandji, P., Chakam, T. P., C., Nkouathio, D. G., Bellon, H., Ruffet, G., 2014. *The Mount Manengouba, a complex volcano of the Cameroon line: Volcanic history, Petrology and geochemical features.* Journal of Africa Earth Sciences 97, 297-321.
- [31] Rogers, N. W., Macdonald, R., Fitton, J. G., George, R., Smith, M., Barreiro, B., 2000. Two mantle plumes beneath the East African Rift system: Sr, Nd and Pb isotope evidence from Kenya rift basalts. Earth Planet. Sci. Lett. 176, 387-400.
- [32] Rogers, N. W., Thomas, L. E., Macdonald, R., Hawkesworth, C. J., Mokadem, F., 2006. ²³⁸U-²³⁰Th disequilibrium in recent basalts and dynamic melting beneath the Kenya rift. Chem. Geol. 234, 148-168.
- [33] Schandl, E. S and Gorton, M. P., 2002. Applications of high field strength elements to discriminate tectonic setting in VMS environments. Economic geology. 97, 629-642.
- [34] Suh C. E., Sparks R. S. J., Fitton J. G., Ayonghe S. N., Annen C., Nana R. and Luckman A., 2003. *The 1999 and 2000 Eruptions of Mount Cameroon: Eruption BehPetrochemistry of Lava*. Bulletin of Volcano No. 4, pp. 267-281.
- [35] Sun, S. S., and McDonough, W. F., 1989. Chemical and isotopic systematics of oceanic basalts: implications for mantle composition and processes. In: Saunders, A.D., Norry, M.J. (Eds.), Magmatism in the Ocean Basins. Geological Society of London Special Publication, 42, p 313-345.
- [36] Wandji, P., Tchokona, S. D., Bardintzeff, J. M., Bellon, H., Platevoet, B., 2008. *Rhyolite of the Mbèpit Massif in the Cameroon Volcanic Line: an early extrusive volcanic episode of Eocene age.* Mineralogy and petrology. 94, p271-286.
- [37] Wandji, P., Tsafack, J. P. F., Bardintzeff, J. M., Nkouathio, D. G., Kagou D. A., Bellon, H., Guillou, H., 2009. Xenoliths of dunites, wehrlites and clinopyroxenite in the basanites from Batoke volcanic cone (Mount Cameroon, Central Africa): petrogenetic implications. Mineral Petrol 96(1):81-98.
- [38] Yokoyama, T., Aka, F.T., Kusakabe, M., Nakamura, E., 2007. Plume–lithosphere interaction beneath Mount. Cameroon volcano, West Africa: constraints from 238U–230Th–226Ra and Sr–Nd–Pb isotopic systematics. Geochimica and Cosmochimica Acta 71, p1835-1854.
- [39] Zhang, J.J., Zeng, Y.F., Zhao, Z.F., 2009. Geochemical evidence for interaction between oceanic crust and lithospheric mantle in the origin of Cenozoic continental basalt in east central China. Lithos 110 p305-326.