LA-13113-MS

Geochemistry of the Lathrop Wells Volcanic Center

RECEIVED
APR 0 1 1996
OSTI

Los Alamos
NATIONAL LABORATORY

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

This work was supported by the Yucca Mountain Site Characterization Office as part of the Civilian Radioactive Waste Management Program. This project is managed by the U.S. Department of Energy, Yucca Mountain Site Characterization Project.

LA-13113-MS

UC-802
Issued: March 1996

Geochemistry of the Lathrop Wells Volcanic Center

Frank V. Perry
Kelly T. Straub

Los Alamos
NATIONAL LABORATORY
Los Alamos, New Mexico 87545

Geochemistry of the Lathrop Wells Volcanic Center

by

Frank V. Perry and Kelley T. Straub

ABSTRACT

Over 100 samples have been gathered from the Lathrop Wells volcanic center to assess different models of basalt petrogenesis and constrain the physical mechanisms of magma ascent in the Yucca Mountain region. Samples have been analyzed for major and trace-element chemistry, Nd, Sr and Pb isotopes, and mineral chemistry. All eruptive units contain olivine phenocrysts, but only the oldest eruptive units contain plagioclase phenocrysts. Compositions of minerals vary little between eruptive units. Geochemical data show that most of the eruptive units at Lathrop Wells defined by field criteria can be distinguished by major and trace-element chemistry. Normative compositions of basalts at Lathrop Wells correlate with stratigraphic position. The oldest basalts are primarily nepheline normative and the youngest basalts are exclusively hypersthene normative, indicating increasing silica saturation with time. Trace-element and major-element variations among eruptive units are statistically significant and support the conclusion that eruptive units at Lathrop Wells represent separate and independent magma batches. This conclusion indicates that magmas in the Yucca Mountain region ascend at preferred eruption sites rather than randomly.

Introduction

The Lathrop Wells volcanic center is the youngest volcanic center in the Yucca Mountain region and has been the primary focus of volcanism studies for the past several years (Crowe et al., 1995). The possibility that the Lathrop Wells center is *polycyclic* (i.e., eruptive activity spanning >10,000 years and involving multiple, independent magma batches) has required an unprecedented level of detail of field and geochronology studies, as well as comprehensive sampling of multiple eruptive units to characterize the geochemistry and assess alternative petrogenetic models (Study Plan 8.3.1.8.5.1, Characterization of Volcanic Features). Approximately 140 geochemical samples have been gathered from the major time-stratigraphic volcanic units of the Lathrop Wells center; subsets of these samples have been analyzed for major-elements, trace-elements, Sr, Nd and Pb isotopic ratios and mineral chemistry.

Geochemical data from Lathrop Wells were obtained for three purposes: (1) to model the magmatic evolution of the volcanic center in order to constrain the nature and dynamics of magma generation and ascent in the Yucca Mountain region, (2) to aid in interpreting the eruptive history of the volcano, primarily by geochemical correlation of eruptive units, and (3) to correlate ashes found in trenched fault exposures near Yucca Mountain with dated eruptive events at Lathrop Wells, thereby constraining the age and timing of fault movement near Yucca Mountain.

The purpose of this report is to present in a single reference all geochemical data obtained from the Lathrop Wells center to date and to describe the basic characteristics of the data. Modeling of the geochemical data to determine the origin of magmas and magmatic evolution of the Lathrop Wells center will be completed in FY96. Sampling, analysis, and correlation of ashes from trenched fault exposures will be completed in FY95.

Overview and Sampling Strategy of the Lathrop Wells Volcanic Center

The Lathrop Wells volcanic center is located approximately 20 km south of the potential Yucca Mountain repository immediately north of interstate highway 95 (Fig. 1). Field, geomorphic, geochronologic and trenching studies have led to the conclusion that the Lathrop Wells center formed during four main eruptive episodes separated by significant periods of inactivity (Fig. 2). Field evidence of significant gaps in eruptive activity between major eruptive episodes includes development of soil horizons, erosional unconformities, and differences in the degree of geomorphic preservation of eruptive features (Crowe et al., 1995). Each of the four major eruptive episodes at Lathrop Wells is defined as a *chronostratigraphic unit*, and contains one or more *eruptive units* (a volcanic deposit

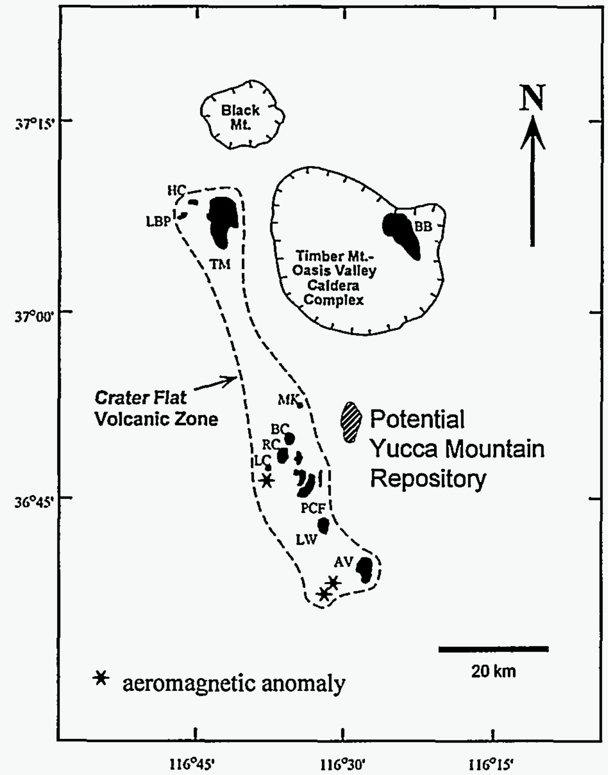


Figure 1. Location of Lathrop Wells in relation to the potential Yucca Mountain repository. From oldest to youngest, basaltic volcanic centers are Thirsty Mesa (TM), Buckboard Mesa (BB), Amargosa Valley (AV), Crater Flat (CF), Sleeping Butte (SB) and Lathrop Wells (LW).

[lava flow or scoria fall] formed during a single time-synchronous volcanic eruption).

Chronostratigraphic unit I is the oldest eruptive episode and includes four lava flows (Ql1a-d) erupted from multiple, north to northwest-trending fissure zones marked by scoria and spatter deposits (Fig. 2). Chronostratigraphic unit II consists of the largest volume lava flow erupted at Lathrop Wells (Ql2a) on the east side of the center, several minor flow lobes on the northeast side of the center, and two sets of northwest trending scoria mounds. A widespread and voluminous scoria-fall and pyroclastic deposit (Qs2fs) is interbedded with the lava flows of chronostratigraphic unit II and is inferred to have erupted from a vent concealed beneath the main cinder cone of chronostratigraphic unit III. The eruptive events of chronostratigraphic unit III formed the main cinder cone (Qs3) on the west side of the center and a small-volume lava flow (Ql3) erupted from a vent on the northeast side of the center. Chronostratigraphic unit IV consists of three small-volume tephra units (Qs4a-c) erupted from a group of inferred vents south of the main cinder cone which have presumably been removed by commercial quarrying activity

The strategy for geochemical sampling at Lathrop Wells was developed to answer the question of whether separate eruptive units defined by field geologic studies have distinct geochemical compositions. If geochemical variations exist, petrologic modeling can be used to infer the magmatic processes responsible for the variations, and thus provide insight into the physical processes responsible for the formation of basaltic volcanoes in the Yucca Mountain region. Because the range of geochemical variation at Lathrop Wells was assumed to be small, an initial concern was whether internal heterogeneity within individual eruptive units was greater than potential variations among eruptive units. For this reason, several (generally 3-6) samples were taken from each eruptive unit to establish the degree of internal geochemical variation, and to allow statistical comparison of eruptive units (Fig. 3).

Results

Geochemical data from the Lathrop Wells volcanic center was gathered as part of Study Plan 8.3.1.8.5.1, Characterization of Volcanic Features. These data include whole-rock major-element and trace-element data obtained by x-ray fluorescence (XRF), whole-rock trace-element data obtained by instrumental neutron activation analysis (INAA) and isotope dilution, whole-rock Nd, Sr and Pb isotopic analyses obtained by solid source mass spectrometry, and mineral chemistry obtained by electron microprobe. In this report, all analytical results presented in tables and graphs are grouped by chronostratigraphic unit or eruptive unit.

Major-element chemistry

One hundred nineteen whole-rock samples from Lathrop Wells were analyzed for major-element analyses at Los Alamos by XRF following the methods described in Los Alamos Detailed Procedure LANL-EES-DP-111, R3 (appendix A). The range of major-element variation among basalts from the Lathrop Wells center is not large. All are classified as alkali basalts in terms of total alkalis versus silica, using the classification of Cox et al., 1979 (Fig. 4).

A commonly used indicator of the degree of major-element evolution of a basalt due to fractional crystallization is *Mg number*, defined as:

$\left[\left(\frac{Mg}{Mg + Fe^{2+}}\right) \times 100\right]$, where Mg and Fe are cation

Lathrop Wells Volcanic Center

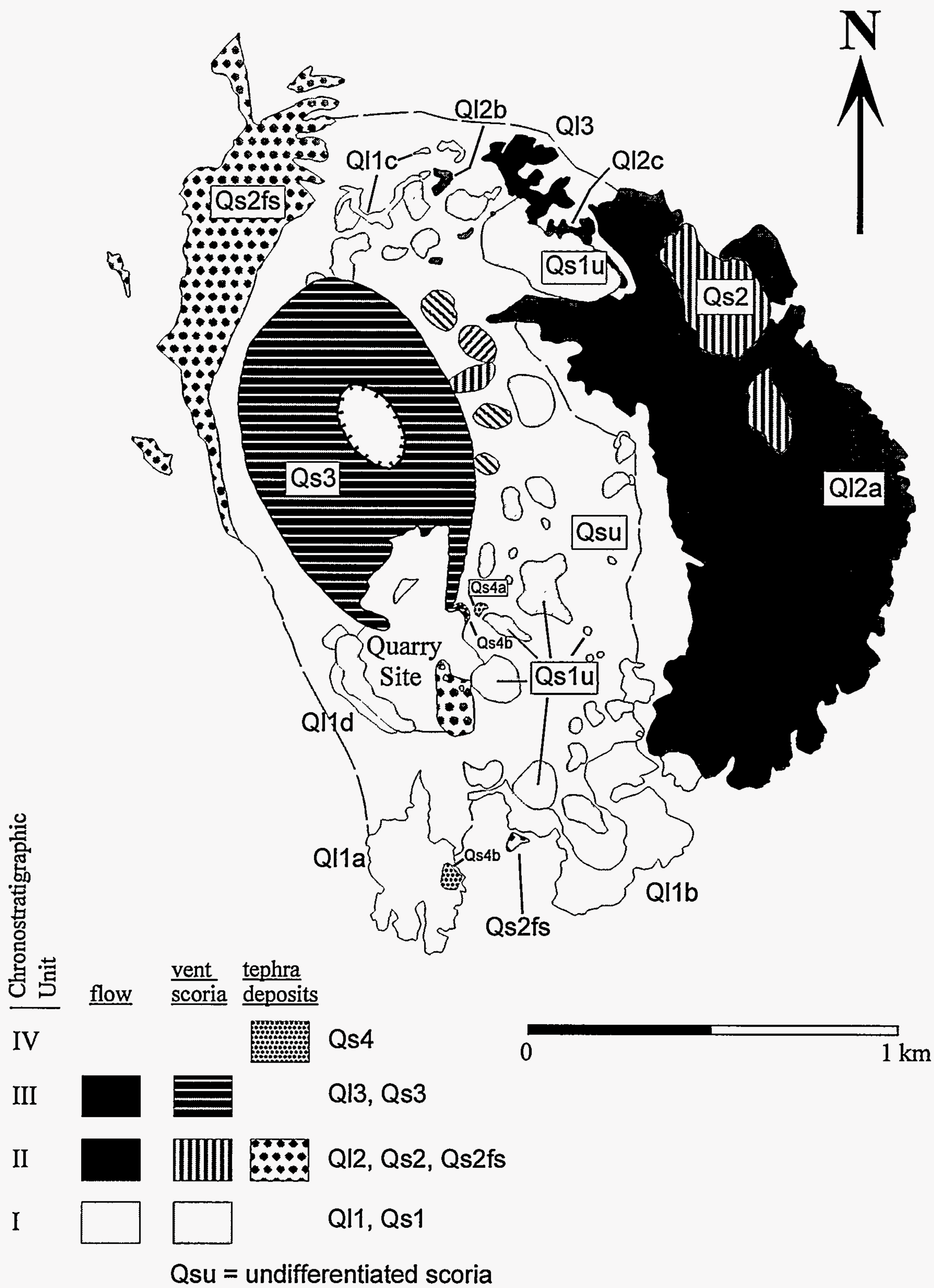


Figure 2. Geologic map of the Lathrop Wells volcanic center.

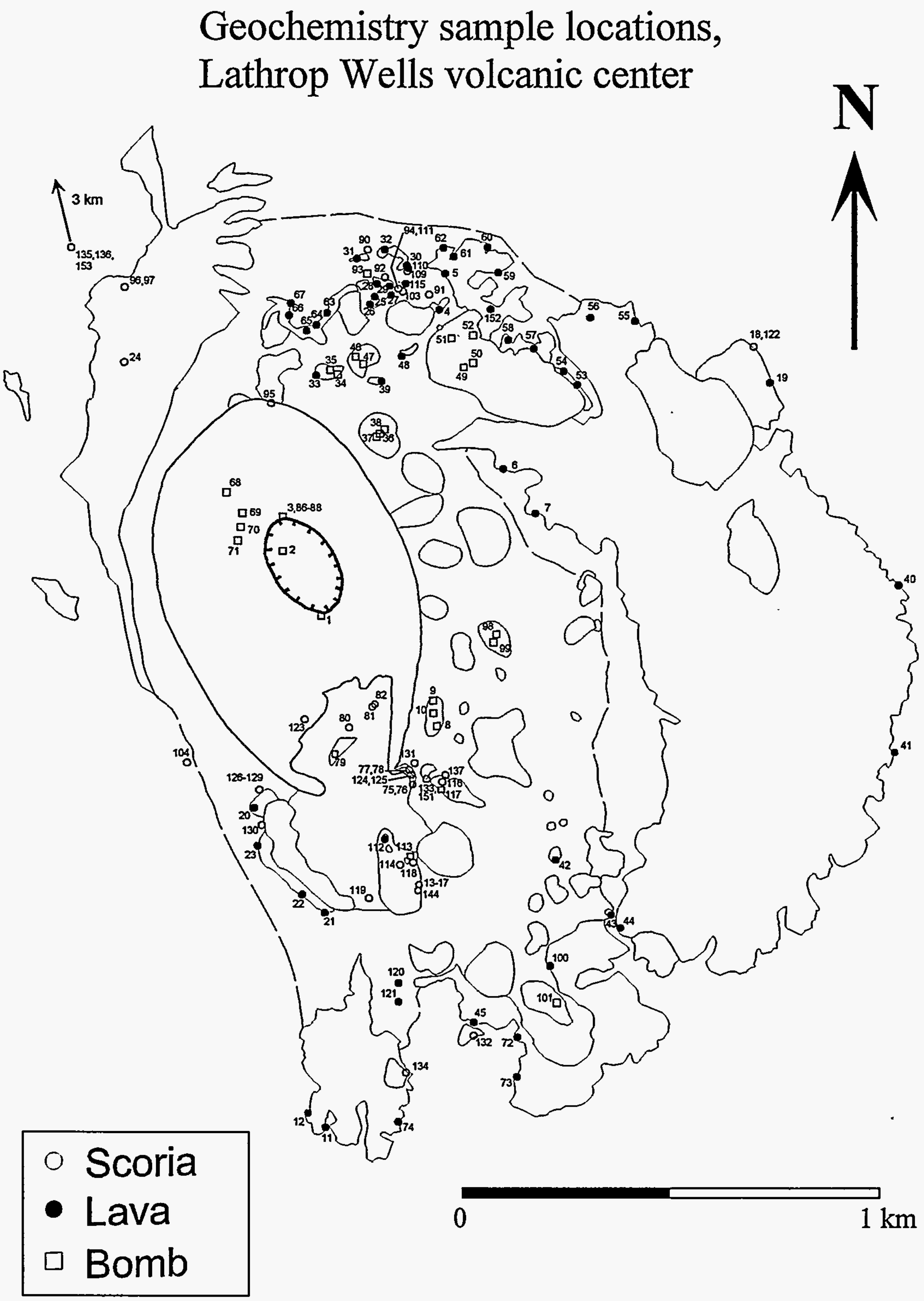


Figure 3. Geochemistry sample locations at the Lathrop Wells volcanic center.

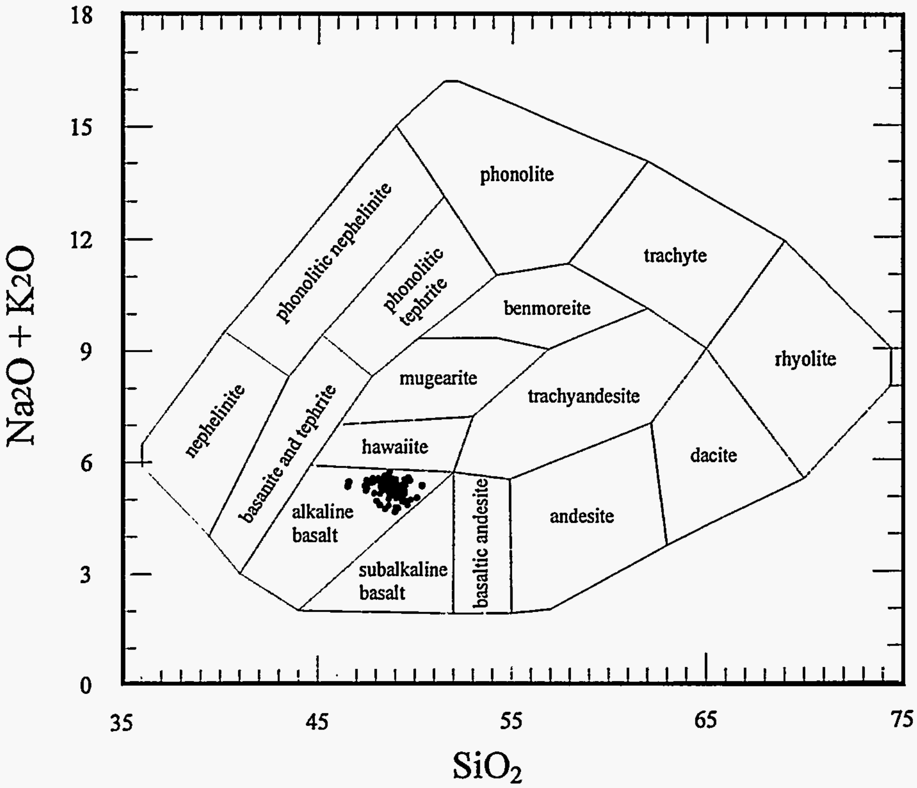


Figure 4. Alkalis versus silica for basalts of Lathrop Wells. All of the basalts of Lathrop Wells are classified as alkaline basalt according to the classification scheme of Cox et al. (1979).

abundances. Unfractionated, primitive basalts in equilibrium with mantle olivine have Mg numbers in the range 68-72. Mg numbers of Lathrop Wells basalt cluster tightly around a value of about 54 (Fig. 5), indicating significant fractionation of either olivine or clinopyroxene prior to eruption (Crowe et al., 1995).

Normative compositions of Lathrop Wells basalt range from about 3% normative nepheline to 15% normative hypersthene (appendix A). The variations in normative composition generally correlate with chronostratigraphic unit, with a trend of increasing silica saturation with decreasing age (Fig. 6). Basalts of chronostratigraphic unit I are primarily nepheline normative, basalts of chronostratigraphic unit II contain both normative nepheline and hypersthene, basalts of chronostratigraphic unit III are primarily hypersthene normative, and basalts of chronostratigraphic unit IV are exclusively hypersthene normative with normative hypersthene contents as high as 15%.

Trace-element chemistry

Whole rock trace-element analyses of V, Cr, Ni, Zn, Rb, Sr, Y, Zr, Nb and Ba were performed at Los Alamos by XRF using the procedures described in LANL-EES-DP-111, R3 (appendix A). Appendix B lists whole rock trace-element INAA analyses of Rb, Sc, Co, Sr, Ba, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, Hf, Ta and Th for 99 samples analyzed at Washington University, St. Louis, using procedures described in Korotev (1987). For each of three sample groups analyzed at Washington University, four blind replicate samples were analyzed to monitor analytical precision (appendix B:2). The replicate analyses indicate that all trace elements except Rb and Nd have analytical precision of <3%. Appendix C lists 21 samples analyzed for Sm, Nd, Rb, Sr and Pb by isotope dilution at the University of Colorado using procedures described in Farmer et al. (1991). Analytical precision based on 6 replicate analyses is <1% for Sm, Nd, and Sr, and approximately 2% and 3% for Rb and Pb, respectively (appendix C:2).

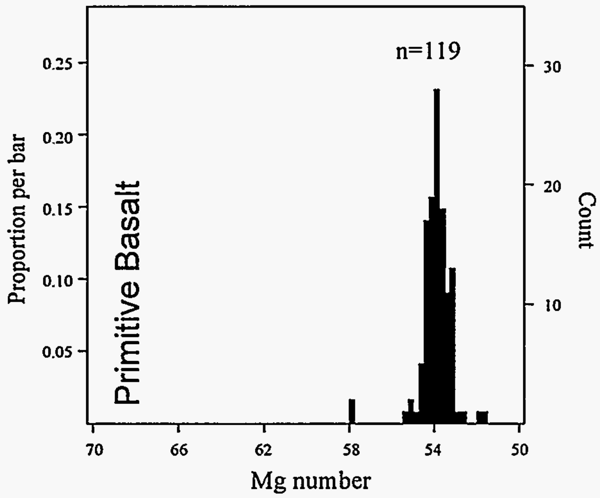


Figure 5. Histogram of Mg numbers for basalts of Lathrop Wells.

Lathrop Wells basalts are notable in having high concentrations of trace elements such as the rare earth elements, Sr, Ba and Th compared to typical alkali basalts, combined with low concentrations of Rb (Vaniman et al., 1982). While part of the trace-element enrichment may be due to fractionation processes, an unusual trace-element enriched lithospheric mantle source is probably the primary cause (Vaniman et al., 1982; Farmer et al., 1989).

Isotope chemistry

Isotopic compositions of Nd, Sr and Pb for 21 Lathrop Wells basalts (appendix C) were analyzed at the University of Colorado using methods described in Farmer et al. (1991). Analytical precision based on 6 replicate analyses is 0.001% for $^{143}Nd/^{144}Nd$, 0.002% for $^{87}Sr/^{86}Sr$, 0.114% for $^{208}Pb/^{204}Pb$, 0.085% for $^{207}Pb/^{204}Pb$ and 0.058% for $^{206}Pb/^{204}Pb$ (appendix C:2).

The total range in Nd and Sr isotopic compositions at Lathrop Wells is fairly small with ε_{Nd} values ranging from -9.7 to -10.3 and $^{87}Sr/^{86}Sr$ ranging from about 0.7070 to 0.7071 (Fig. 7). As a group, samples of chronostratigraphic unit I have slightly higher $^{87}Sr/^{86}Sr$ (mean=0.707066, n=5) than samples of chronostratigraphic unit II (mean=0.0707017, n=6). This difference is statistically significant at the 95% confidence level using the two-tailed *t* test. The Sr and Nd isotopic compositions of Lathrop Wells basalts are highly unusual for continental alkali basalts of the western U.S. and indicate derivation from a trace-element enriched lithospheric mantle source (Farmer et al., 1989).

Petrography and Mineral Chemistry

Basalts of Lathrop Wells are sparsely porphyritic with phenocrysts of olivine and plagioclase in a fine-grained groundmass of plagioclase, olivine, titanomagnetite and clinopyroxene. The percentage of olivine phenocrysts is fairly constant at 1-4% for basalts of most eruptive units (Fig. 8). Plagioclase phenocrysts and microphenocrysts are most abundant in eruptive units of chronostratigraphic unit I. Plagioclase phenocrysts are largely absent in basalts of chronostratigraphic unit II, III and IV (Fig. 8).

Mineral chemistry was obtained by electron microprobe using methods described in Los Alamos Detailed Procedure LANL-EES-DP-131, R0. Mineral chemistry does not vary significantly by eruptive unit. The maximum forsterite content of analyzed olivine phenocrysts from all eruptive units is 78±1% (appendix D:1-8). In every case, olivine from lava flows is more zoned (appendix D:1-3,5) than olivine from tephra units (appendix D:4, 6-8) probably because tephra was quickly quenched upon eruption, while lava flows cooled more slowly, allowing continued crystal growth after eruption. Olivine from tephra units show very limited zoning (<2% forsterite content) and also in some cases display slight reverse zoning (e.g., appendix D:6). Compositions of olivine are listed in appendix E:1-8.

Plagioclase phenocrysts occur in units Ql1b, Ql1c, and Ql1d of chronostratigraphic unit I. The phenocrysts are moderately zoned labradorite with An contents ranging from about An 69 to An 60 (appendix D:9-10). Compositions of groundmass plagioclase in lavas of chronostratigraphic unit I (Ql1d and Ql1b) extend to significantly more sodic compositions (appendix D:11-12) while compositions of groundmass plagioclase in lavas of chronostratigraphic unit II and III (Ql2a and Ql3) include compositions as calcic as phenocrysts in lavas of chronostratigraphic unit I (appendix D:13-14). Compositions of plagioclase are listed in appendix E:9-12

Clinopyroxene occurs as a groundmass phase in all of the lava units at Lathrop Wells. We analyzed groundmass clinopyroxene from eruptive units Ql1d and Ql2a. Clinopyroxenes from unit Ql1d have higher MgO and less TiO_2 than clinopyroxene from Ql2a (appendices D:15-16 and E:13-14).

Magnetite occurs as inclusions in olivine and in the groundmass of all eruptive units. Magnetites are titaniferous (7-22% TiO_2) and magnetite inclusions in olivine generally have higher Cr concentrations that magnetite from the groundmass (appendix E:15-18).

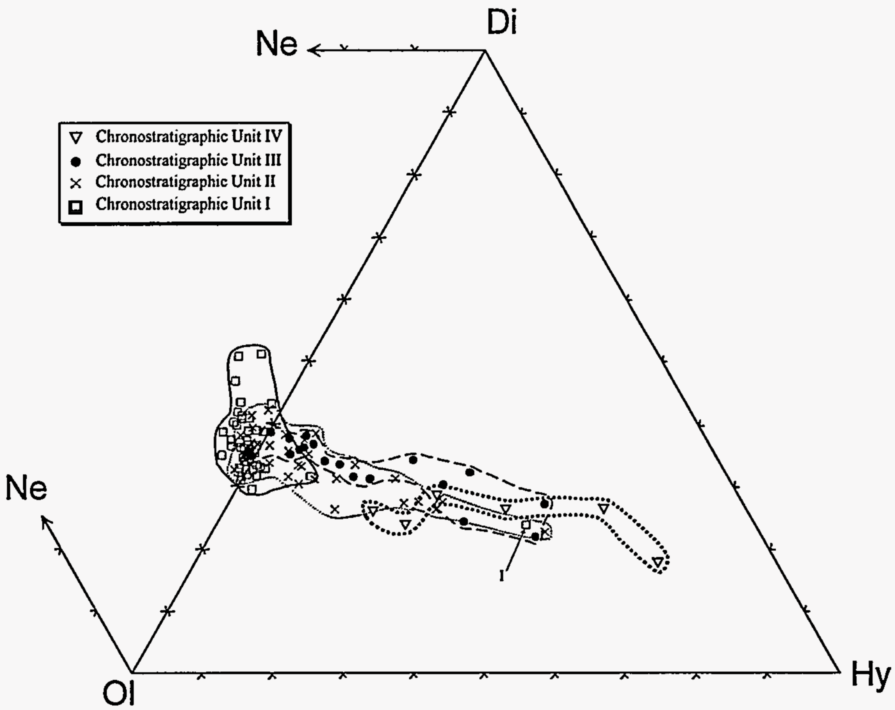


Figure 6. Normative compositions of Lathrop Wells basalts grouped by chronostratigraphic unit (Fig. 2) plotted within ternary fields bounded by Ne-Ol-Di-Hy.

Geochemistry of Eruptive Units

To illustrate the range of compositional variations within eruptive units and differences between eruptive units, we have created normalized line plots of compositions of individual samples grouped by eruptive unit (appendix D:17-28). All of the major and trace elements so plotted are incompatible during fractionation of olivine, the major phenocryst phase in these rocks. Sample compositions were normalized to the average Lathrop Wells composition using a combination of XRF and INAA data (n=99). This approach emphasizes similarities and differences between samples at Lathrop Wells and allows direct inspection of percent differences between samples. In general, individual eruptive units are geochemically homogeneous and show a limited range of geochemical variation (e.g., appendix D:17-20, 24-25, 27-28). The voluminous lava flow and tephra fall deposit of chronostratigraphic unit II appear to have the most internal heterogeneity (appendix D:22-23).

Averaged compositions of the major eruptive units grouped by chronostratigraphic unit are illustrated in appendix D:29-32. In general, individual eruptive units within each of the four chronostratigraphic units share similar geochemical characteristics. All of the eruptive units within chronostratigraphic unit I show similar geochemical patterns that include relatively low concentrations of Th and La, and relatively high concentrations of K, Sr, P, Sm, Eu and Ti compared to the Lathrop Wells compositional mean (appendix D:29). Eruptive units within chronostratigraphic unit II are characterized by a lack of significant variation from the mean Lathrop Wells composition (appendix D:30). The two eruptive units of chronostratigraphic unit III are geochemically similar and are marked by high concentrations of Th and low concentrations of Sr, P, Sm, Eu and Ti (appendix D:31). The three eruptive units of chronostratigraphic unit IV are geochemically diverse. Eruptive unit Qs4b is distinguished from all other eruptive units at Lathrop Wells by having the highest concentrations of Th and Rb (Rb not plotted, see appendices A and B:1), and the lowest concentrations of Sr and Ti (appendix D:32). Eruptive unit Qs4c is characterized by generally low concentrations of all incompatible elements (appendix D:28). The geochemical differences between eruptive units should permit correlation of ashes in trenched fault exposures near Yucca Mountain to individual eruptive units at Lathrop Wells.

Isotope dilution is a high-precision method of determining trace-element concentrations (appendix C:2) and offers an independent method of assessing geochemical differences between eruptive units. The isotope dilution data are compatible with the INAA data

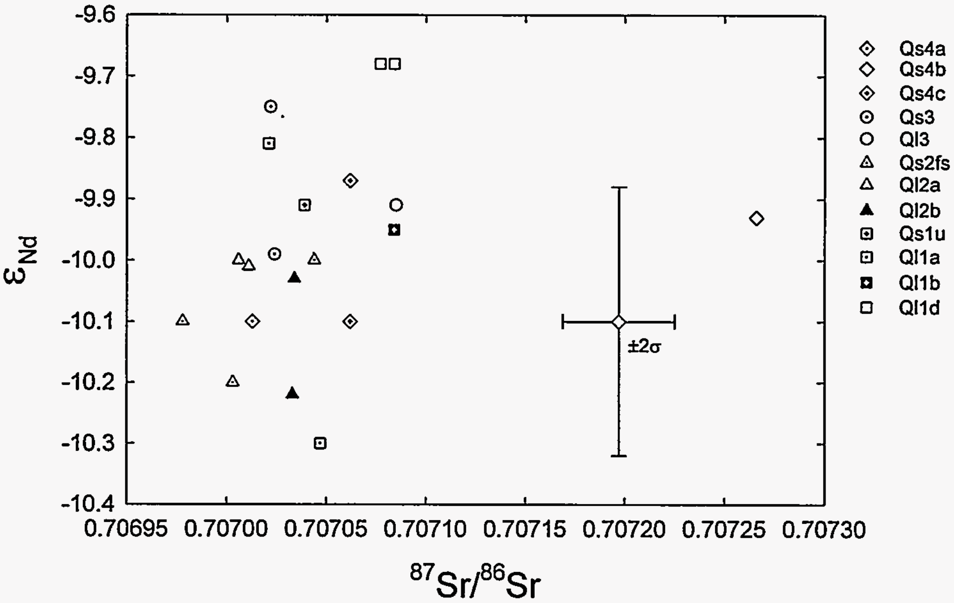


Figure 7. ε_{Nd} versus $^{87}Sr/^{86}Sr$ for eruptive units of the Lathrop Wells volcanic center.

discussed above and show that most eruptive units are geochemically distinct, with eruptive units of chronostratigraphic unit I having the highest concentrations of Sr and the middle rare-earth elements (Nd and Sm), and unit Ql4c having the lowest concentrations of Sr, Nd and Sm (appendix D:33-34).

At what level are differences in the mean compositions of different eruptive units statistically significant? As an example, we consider eruptive units Ql1a and Ql1d, adjacent lava flows which show moderate (1-8%) differences in average elemental concentrations (appendix D:35). To test for the statistical significance of these differences, we use the two-tailed *t* test, which calculates the probability that two sample means are equal. Probabilities of < 0.05 indicate that two sample means represent different populations at the 95% confidence level. In the case of Ql1d and Ql1a, the average concentrations of Ba, Th, K, Ce, Sr and Eu can be distinguished at the 95% confidence level (appendix D:35). From these results, we conclude that differences in average elemental concentrations as small as 1-2% are statistically significant for elements with the highest analytical precision (e.g., Ce, appendix B:2) and are almost always significant for average differences of >3-4%. Differences in average elemental concentrations between eruptive units of different chronostratigraphic units are commonly 5-10% and are >35% in the case of Th (appendix D:29-32).

The capability to geochemically discriminate eruptive units at Lathrop Wells provides a useful tool for constraining the eruptive history of the center and to tie the eruptive history to tectonic studies of the Yucca Mountain region. For example, the most voluminous tephra and pyroclastic surge deposit at Lathrop Wells (Qs2fs) was assumed, by analogy to other basalt centers, to be part of the eruptions which formed the main cinder cone of chronostratigraphic unit III (Figure 2). Because of its volume and widespread distribution, ash of unit Qs2fs is most likely the dominant ash found in fault exposures near Yucca Mountain. Geochemical differences between eruptive units Qs2fs and Qs3 indicate that the two eruptive units are not the same (appendix D:36). This observation, combined with stratigraphic and geomorphic evidence, led to the assignment of unit Qs2fs to chronostratigraphic unit II (Crowe et al., 1995). This interpretation places the inferred correspondence of volcanic and tectonic activity recorded by ashes in fault fissures farther in the geologic past. The ability to discriminate eruptive units at Lathrop Wells will provide the primary basis for correlating basaltic ashes in trenched fault exposures near Yucca Mountain to dated eruptive units at Lathrop Wells.

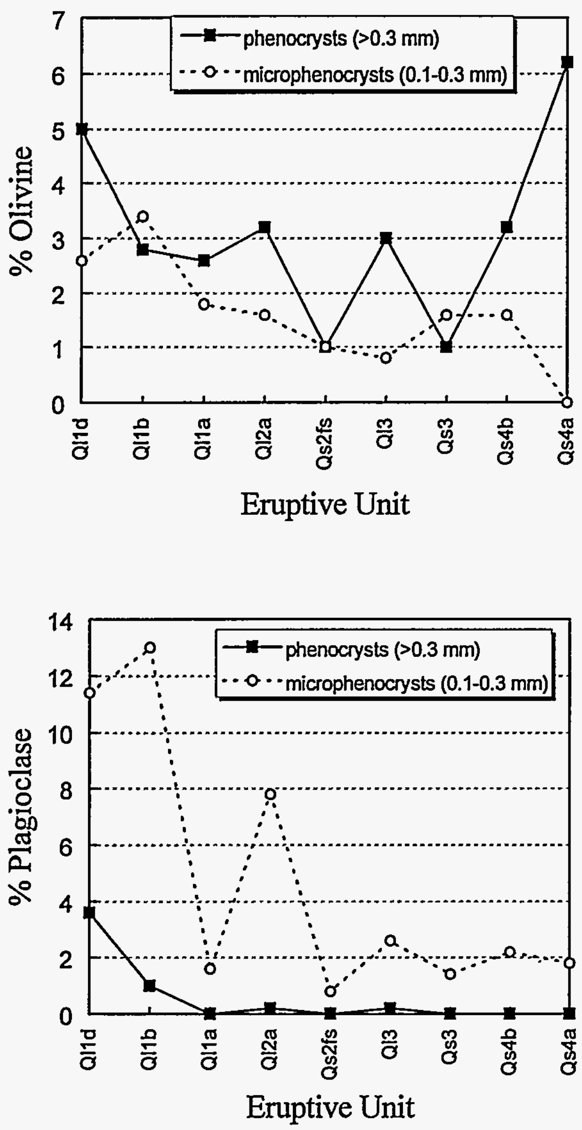


Figure 8. Percent olivine and plagioclase phenocrysts and microphenocrysts determined by point counting for representative samples of eruptive units from the Lathrop Wells volcanic center. Samples counted from each eruptive unit are LW20FVP from Ql1d, LW73FVP from Ql1b, LW11FVP from Ql1a, LW40FVP from Ql2a, LW97FVP from Qs2fs, LW61FVP from Ql3, LW80FVP from Qs3, LW78FVP from Qs4b and LW151 from Qs4a.

The earliest evidence that the Lathrop Wells volcanic center is polycyclic was the recognition of a soil horizon between tephra unit Qs4b and underlying tephra of Qs3, the deposits of the main scoria cone (Wells et al., 1988). The soil was interpreted to represent a hiatus between eruptions at Lathrop Wells of at least several thousand years. An alternative interpretation was that tephra Qs4b is reworked tephra from the slope of the main cinder cone, an interpretation which does not require a polycyclic history of the center (Turrin et al., 1992). Geochemical differences between Qs3 and Ql4b confirm that Ql4b cannot be reworked tephra from Qs3 (appendix D:37). Its unique geochemical composition compared to all other Lathrop Wells eruptive units, combined with a thermoluminescence date of ~ 4 ka on the underlying soil, indicate that it represents a distinct eruptive episode and supports the conclusion that the Lathrop Wells center is polycyclic with eruptions that extended into the Holocene (Crowe et al., 1995).

A final example of how geochemical correlation can provide evidence of polycyclic activity is the relationship between vent conduits and overlying tephra in the southeast quarry area. The tephra overlying these conduits was assumed to be related to the conduits on the basis of field mapping. Geochemical data show that the vent conduits are geochemically similar to lavas of chronostratigraphic unit I and are in the appropriate location for vents of the southern flows of chronostratigraphic unit I (Fig. 2). The overlying tephra unit, however, is geochemically distinct from the vent conduits and most similar to tephra of Qs2fs (appendix D:38). The vent conduits were significantly stripped and eroded before emplacement of the overlying, geochemically distinct tephra, signifying a significant period of geologic time between the emplacement of the conduits and the overlying tephra.

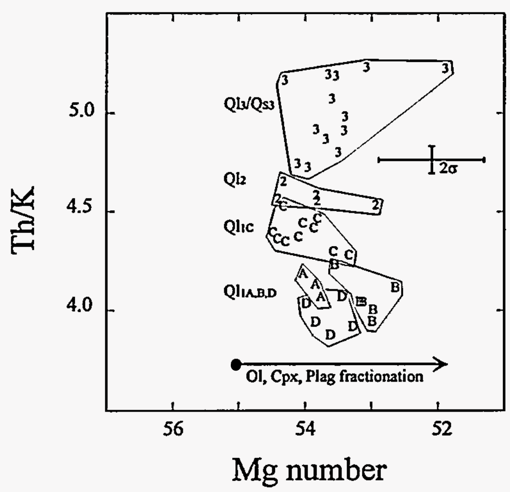


Figure 9. Mg number versus Th/K for selected eruptive units of the Lathrop Wells volcanic center. Arrow represents the qualitative change in Mg number and Th/K for a magma undergoing fractional crystallization of olivine, clinopyroxene, or plagioclase. Different Th/K values of eruptive units indicate that the units are not derived from a single magma undergoing fractional crystallization.

In detail, geochemical differences between eruptive units at Lathrop Wells cannot be accounted for by simple fractional crystallization of a single magma batch (Crowe et al., 1995). For instance, variations of Th/K at the same Mg number for the major eruptive units of chronostratigraphic unit I, II, and III indicate at least 4 separate magma batches. (Fig. 9). Preliminary modeling of more complex magmatic processes including magma recharge also indicate the existence of distinct magma batches.

Implications for Volcanic Risk Assessment

Field, geomorphic and geochemical evidence indicate a complex and extended eruptive history at Lathrop Wells involving multiple magma batches and several eruptive episodes that were separated by significant periods of inactivity. The eruption of several independent magma batches at a single location in the Yucca Mountain region suggests that eruptions in the region will not occur at random locations in the near future (10^4-10^5 years), but probably near the site of previous eruptions at Lathrop Wells. If this conclusion of preferred eruption sites is correct, the calculated probability of magma ascending at the potential Yucca Mountain repository during the next 10,000 years is lower than that calculated for models which assume random sites of future eruptions.

Acknowledgments

Sample and data collection information and documentation for this report are contained in Field Notebooks TWS-EES-13-LV-12-89-03 and EES-13-LV-02-93-07, Sample Logbooks TWS-EES-13-LV-12/89-04, TWS-EES-13-LV-04-91-01 and LA-EES-13-05-94-006, and Scientific Notebooks TWS-EES-13-LV-12-89-05 and TWS-EES-13-07-93-044. The Los Alamos Data Tracking Number for this report is LA000000000099.001. This work was supported by the Yucca Mountain Site Characterization Project Office as part of the Civilian Radioactive Waste Management Program. This program is managed by the U.S. Department of Energy, Yucca Mountain Site Characterization Office.

References

Cox, K. G., J. D. Bell, and R. J. Pankhurst, "The interpretation of igneous rocks," George Allen & Unwin Ltd, London, 450 pp. (1979).

Crowe, B. F. Perry, J. Geissman, L. McFadden, S. Wells, M. Murrell, J. Poths, G. A. Valentine, L. Bowker, and K. Finnegan, "Status of Volcanism Studies for the Yucca Mountain Site Characterization Project," *Los Alamos National Laboratory report* LA-12908-MS (1995)

Farmer, G. L., F. V. Perry, S. Semken, B. Crowe, D. Curtis, and D. J. DePaolo, "Isotopic evidence on the structure and origin of subcontinental lithospheric mantle in southern Nevada," *Journal of Geophysical Research* **94**, 7885-7898 (1989).

Farmer, G. L, D. E. Broxton, R. G. Warren, and W. Pickthorn, "Nd, Sr, and O isotopic variations in metaluminous ash-flow tuffs and related volcanic rocks at the Timber Mountain/Oasis Valley caldera complex, SW Nevada: implications for the origin and evolution of large-volume silicic magma bodies," *Contrib. Mineral. Petrol.* **109**, 53-68 (1991).

Korotev, R. L., "National Bureau of Standards coal flyash (SRM 1663a) as a multielement standard for instrumental neutron activation analysis," *Journal of Radioanalytical and Nuclear Chemistry* **110**, 159-177 (1987).

Turrin, B. D., D. E. Champion, and R. J. Fleck, "Measuring the age of the Lathrop Wells volcanic center at Yucca Mountain-Reply," *Scence* **257**, 556-558 (1992).

Vaniman, D. T., B. M. Crowe, and E. S. Gladney, "Petrology and geochemistry of hawaiite lavas from Crater Flat, Nevada," *Contrib. Mineral. Petrol.* **80**, 341-357 (1982).

Wells, S. G., L. D. McFadden, C. E. Renault, and B. M. Crowe, "Geomorphic assessment of late Quaternary volcanism in the Yucca Mountain area, southern Nevada: Implications for the proposed high-level waste repository," *Geoogy* **18**, 549-553 (1990).

Appendix A

Major, trace-element (determined by XRF) and normative compositions of Lathrop Wells basalts

Sample	LW11FVP	LW12FVP	LW74FVP	LW45FVP	LW72FVP	LW73FVP	LW100FVP	LW120FVP	LW121FVP	LW101FVP	LW30FVP	LW31FVP	LW32FVP	LW63FVP
Unit	Ql1a	Ql1a	Ql1a	Ql1b	Ql1b	Ql1b	Ql1b	Ql1b	Ql1b	Qs1b	Ql1c	Ql1c	Ql1c	Ql1c
SiO_2	48.59	48.63	48.49	47.83	47.89	48.47	48.55	48.25	48.62	48.94	47.55	48.82	48.25	48.31
TiO_2	1.98	1.97	2.01	2.02	1.99	2.02	2.02	2.04	2.01	2.01	1.89	1.93	1.96	1.92
Al_2O_3	16.80	16.95	16.64	16.45	16.60	16.71	16.61	16.87	16.74	16.79	16.26	16.74	16.79	16.65
Fe_2O_3T	11.78	11.82	11.72	11.91	11.80	11.85	11.88	11.95	11.80	11.88	11.36	11.58	11.70	11.56
Fe_2O_3	1.77	1.77	1.76	1.79	1.77	1.78	1.78	1.79	1.77	1.78	1.70	1.74	1.75	1.73
FeO	9.01	9.04	8.97	9.11	9.03	9.07	9.09	9.14	9.03	9.09	8.69	8.86	8.95	8.84
MnO	0.18	0.17	0.17	0.18	0.17	0.18	0.18	0.18	0.18	0.18	0.17	0.17	0.17	0.18
MgO	5.89	5.93	5.93	5.81	5.72	5.88	5.80	5.80	5.88	5.77	5.84	5.82	5.75	5.92
CaO	8.29	8.41	8.55	8.42	8.66	8.48	8.68	8.46	8.59	8.43	9.36	8.54	8.50	8.45
Na_2O	3.57	3.48	3.66	3.65	3.57	3.58	3.59	3.61	3.59	3.59	3.44	3.58	3.53	3.60
K_2O	1.92	1.93	1.89	1.88	1.88	1.84	1.91	1.90	1.86	1.91	1.83	1.86	1.84	1.81
P_2O_5	1.24	1.25	1.21	1.26	1.25	1.26	1.24	1.27	1.26	1.25	1.19	1.21	1.24	1.23
Total	100.24	100.56	100.27	99.40	99.52	100.27	100.46	100.31	100.53	100.75	98.87	100.24	99.73	99.61
Mg#	53.82	53.90	54.08	53.19	53.03	53.60	53.23	53.05	53.73	53.10	54.48	53.92	53.40	54.38
V	179.1	179.5	175.9	192.1	183.0	186.9	190.6	164.7	203.5	183.8	168.4	180.5	183.7	177.9
Cr	112.8	115.0	119.4	108.7	106.4	101.0	106.6	122.9	127.0	123.2	113.7	142.2	110.0	131.0
Ni	60.0	60.7	57.4	49.1	53.1	62.2	56.5	59.0	56.3	55.0	54.8	64.0	57.4	57.2
Zn	128.9	124.9	138.3	139.5	133.6	84.1	143.2	145.7	143.8	140.8	126.9	127.4	127.7	131.0
Rb	19.4	19.9	15.7	19.8	19.7	15.3	18.7	17.2	14.1	19.8	19.7	18.7	14.6	19.1
Sr	1490	1488	1492	1530	1578	1536	1541	1540	1521	1519	1453	1467	1497	1466
Y	27.9	30.8	36.0	23.1	27.2	24.6	21.4	30.9	23.5	29.9	29.9	19.2	28.0	27.0
Zr	372.8	366.2	377.2	383.8	354.0	382.4	374.4	386.0	370.7	368.0	366.3	377.3	367.0	370.2
Nb	30.8	27.1	30.6	29.7	27.2	37.6	34.4	28.5	32.4	35.6	30.1	34.3	31.0	30.1
Ba	1373	1391	1464	1424	1354	1428	1249	1280	1309	1312	1337	1389	1435	1412
Or	11.36	11.42	11.17	11.13	11.13	10.90	11.30	11.22	10.99	11.27	10.80	10.99	10.89	10.68
Ab	29.65	29.36	28.45	27.97	27.57	29.37	28.45	28.53	29.21	30.15	25.16	29.86	29.17	29.34
An	24.26	25.02	23.52	23.06	23.84	24.17	23.67	24.32	24.18	24.16	23.61	24.24	24.65	24.03
Ne	0.29	0.07	1.34	1.57	1.40	0.52	1.04	1.10	0.63	0.13	2.15	0.21	0.36	0.62
Di	7.94	7.76	9.78	9.37	9.77	8.75	10.02	8.43	9.15	8.55	13.10	9.11	8.49	8.84
Hy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ol	16.81	16.99	16.11	16.23	15.86	16.51	15.96	16.56	16.35	16.45	14.55	16.12	16.31	16.39
Mt	2.56	2.57	2.55	2.59	2.57	2.58	2.58	2.60	2.57	2.58	2.47	2.52	2.54	2.51
Il	3.76	3.75	3.82	3.83	3.77	3.84	3.83	3.87	3.82	3.81	3.59	3.66	3.72	3.64
Ap	2.97	3.00	2.91	3.02	2.99	3.01	2.98	3.04	3.01	2.99	2.84	2.91	2.97	2.94

FeO, Fe_2O_3 and Mg# calculated assuming Fe^{3+}/Fe total = 0.15. K_2O values in parentheses are from oxidized scoria that has probably been affected by alteration.

Analytical uncertainties (2 sigma) are 1% for CaO, 2% for TiO_2, Al_2O_3, Fe_2O_3, MgO, K_2O, P_2O_5 and Sr, 3% for SiO_2 and Na_2O, 4% for Ba, 8% for MnO and Zr, 10% for Cr and Zn, 13% for V, 20% for Ni, Rb, Y and Nb.

Appendix A

Major, trace-element (determined by XRF) and normative compositions of Lathrop Wells basalts

Sample	LW64FVP	LW65FVP	LW66FVP	LW67FVP	LW110FVP	LW115FVP	LW93FVP	LW109FVP	LW20FVP	LW21FVP	LW22FVP	LW23FVP	LW79FVP	LW01FVP
Unit	Ql1c	Ql1c	Ql1c	Ql1c	Ql1c	Ql1c	Qs1c	Qs1c	Ql1d	Ql1d	Ql1d	Ql1d	Qs1d	Qs1r
SiO_2	48.24	48.57	48.55	48.56	49.67	49.46	49.03	48.70	48.58	46.53	47.43	47.74	48.41	48.66
TiO_2	1.93	1.97	1.92	1.92	1.97	1.95	1.97	1.92	2.04	1.98	2.06	2.03	2.04	1.97
Al_2O_3	16.76	16.94	16.98	16.64	17.03	17.16	16.93	16.60	16.69	16.06	16.60	16.39	16.72	16.77
Fe_2O_3T	11.52	11.66	11.53	11.65	11.71	11.71	11.68	11.55	12.02	11.88	12.15	12.02	12.12	11.78
Fe_2O_3	1.73	1.75	1.73	1.75	1.76	1.76	1.75	1.73	1.80	1.78	1.82	1.80	1.82	1.77
FeO	8.81	8.92	8.82	8.91	8.96	8.96	8.94	8.84	9.20	9.09	9.30	9.20	9.27	9.01
MnO	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.18	0.18	0.17	0.17	0.17
MgO	5.84	5.79	5.78	6.00	5.92	5.99	5.94	5.82	6.03	5.83	6.13	5.98	5.99	5.84
CaO	8.54	8.31	8.51	8.41	8.42	8.40	8.34	8.50	8.53	9.12	8.40	8.61	8.28	8.41
Na_2O	3.51	3.61	3.62	3.63	3.70	3.64	3.59	3.72	3.61	3.51	3.55	3.58	3.50	3.53
K_2O	1.85	1.87	1.84	1.85	1.85	1.86	1.87	1.99	1.88	1.82	1.80	1.85	1.87	1.84
P_2O_5	1.20	1.25	1.22	1.22	1.22	1.21	1.22	1.18	1.29	1.26	1.31	1.24	1.30	1.24
Total	99.56	100.13	100.12	100.06	101.65	101.55	100.73	100.14	100.85	98.15	99.60	99.61	100.39	100.20
Mg#	54.16	53.63	53.86	54.54	54.09	54.36	54.22	53.98	53.90	53.34	54.04	53.68	53.50	53.60
V	183.5	178.2	178.4	177.8	182.1	193.7	173.7	180.9	173.1	180.6	184.6	185.9	176.7	186.5
Cr	124.9	109.3	103.3	124.7	121.7	120.6	119.3	113.9	103.8	119.6	106.2	109.3	123.4	115.8
Ni	54.9	54.8	51.6	59.8	52.2	47.5	51.2	58.6	61.5	61.3	61.7	66.9	66.2	52.3
Zn	128.5	137.2	131.0	134.9	137.1	131.8	142.9	137.8	132.6	130.5	123.3	135.8	134.2	133.8
Rb	18.7	16.2	19.4	17.3	20.8	19.1	18.9	18.7	14.5	18.6	14.0	14.4	18.4	17.1
Sr	1480	1500	1485	1460	1470	1483	1471	1470	1552	1533	1556	1547	1532	1516
Y	28.6	31.3	28.6	30.6	30.6	31.6	25.6	25.2	31.4	29.9	23.5	26.1	27.5	25.9
Zr	372.6	369.2	362.0	366.3	368.8	375.1	375.9	376.4	381.8	367.2	381.8	379.4	367.6	381.4
Nb	27.0	29.3	36.6	35.2	31.6	32.4	34.4	35.3	26.6	27.4	29.4	33.6	26.0	37.1
Ba	1370	1375	1368	1440	1341	1338	1325	1289	1326	1318	1315	1280	1354	1428
Or	10.95	11.03	10.88	10.93	10.96	11.02	11.04	11.77	11.10	10.73	10.64	10.93	11.06	10.86
Ab	28.78	30.04	29.34	29.39	31.28	30.81	30.37	28.22	28.93	23.82	27.58	27.15	29.59	29.88
An	24.61	24.63	24.75	23.77	24.50	25.08	24.68	22.83	23.89	22.81	24.15	23.28	24.51	24.59
Ne	0.50	0.26	0.71	0.70	0.00	0.00	0.00	1.75	0.88	3.17	1.32	1.71	0.00	0.00
Di	8.87	7.66	8.55	8.95	8.37	7.89	7.89	10.30	8.99	12.47	8.13	10.10	7.38	8.20
Hy	0.00	0.00	0.00	0.00	0.21	0.07	0.41	0.00	0.00	0.00	0.00	0.00	0.55	0.58
Ol	16.20	16.61	16.22	16.58	16.50	16.91	16.52	15.68	16.84	15.16	17.43	16.36	17.04	16.21
Mt	2.51	2.54	2.51	2.53	2.55	2.55	2.54	2.51	2.61	2.58	2.64	2.61	2.64	2.56
Il	3.66	3.75	3.65	3.65	3.73	3.70	3.74	3.65	3.88	3.77	3.91	3.86	3.87	3.74
Ap	2.88	3.00	2.92	2.93	2.92	2.90	2.92	2.82	3.09	3.00	3.13	2.96	3.12	2.96

Appendix A

Major, trace-element (determined by XRF) and normative compositions of Lathrop Wells basalts

Sample	LW71FVP	LW53FVP	LW112FVP	LW08FVPA	LW09FVP	LW10FVPA	LW33FVP	LW34FVP	LW35FVP	LW42FVP	LW43FVP	LW46FVP	LW47FVP	LW49FVP
Unit	Qs1r	Ql1u	Ql1u	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u
SiO_2	48.45	48.12	49.51	48.78	48.27	48.42	48.95	48.80	48.80	46.60	47.52	48.32	48.60	48.56
TiO_2	2.04	2.04	2.02	2.00	1.97	1.98	1.95	1.94	1.94	1.96	2.01	1.96	1.96	1.97
Al_2O_3	16.77	16.80	16.84	16.65	16.57	16.52	17.10	16.90	16.93	16.09	16.24	16.80	16.75	16.68
Fe_2O_3T	11.94	11.99	11.43	11.80	11.67	11.68	11.69	11.73	11.64	11.53	11.88	11.67	11.72	11.74
Fe_2O_3	1.79	1.80	1.71	1.77	1.75	1.75	1.75	1.76	1.75	1.73	1.78	1.75	1.76	1.76
FeO	9.14	9.17	8.74	9.03	8.93	8.94	8.94	8.97	8.91	8.82	9.09	8.93	8.97	8.98
MnO	0.17	0.18	0.19	0.17	0.17	0.18	0.17	0.18	0.18	0.17	0.17	0.17	0.17	0.17
MgO	5.81	5.98	6.01	5.79	5.86	5.67	5.86	5.98	5.78	5.51	5.76	5.82	5.91	5.96
CaO	8.36	8.46	8.36	8.66	8.58	8.69	8.37	8.29	8.45	8.56	8.29	8.41	8.37	8.39
Na_2O	3.68	3.72	3.25	3.58	3.56	3.48	3.65	3.58	3.59	3.63	3.62	3.52	3.52	3.48
K_2O	1.93	1.81	1.67	1.86	1.88	1.89	1.86	1.86	1.89	1.82	1.86	1.90	1.87	1.88
P_2O_5	1.26	1.27	1.24	1.23	1.26	1.25	1.25	1.24	1.24	1.23	1.23	1.21	1.23	1.22
Total	100.40	100.37	100.51	100.52	99.78	99.76	100.85	100.49	100.43	97.09	98.59	99.77	100.10	100.04
Mg#	53.13	53.75	55.06	53.34	53.91	53.09	53.85	54.30	53.65	52.69	53.04	53.76	54.00	54.18
V	184.2	182.7	208.9	184.6	179.6	177.0	185.7	188.0	185.0	176.9	174.0	167.4	190.1	180.3
Cr	113.6	110.6	112.1	121.5	117.1	116.2	120.3	132.0	121.3	107.3	98.9	115.6	123.9	113.4
Ni	59.5	69.1	56.3	58.9	57.0	51.3	53.0	54.8	52.6	53.8	54.1	53.8	56.0	62.2
Zn	135.0	113.0	157.9	142.4	136.0	142.1	120.6	122.1	125.7	148.9	139.5	136.2	107.6	141.1
Rb	17.0	14.4	17.1	19.5	18.9	18.1	12.4	16.8	19.5	13.8	17.2	17.5	17.4	18.6
Sr	1577	1572	1550	1525	1522	1541	1455	1460	1481	1510	1509	1470	1485	1478
Y	29.4	25.9	24.1	26.9	35.6	27.2	33.2	25.6	22.8	22.4	24.8	29.8	29.0	22.8
Zr	365.8	364.7	386.9	363.4	382.0	369.9	365.7	360.7	365.8	377.3	387.4	391.9	370.0	373.8
Nb	28.4	30.3	34.2	29.7	27.7	31.2	28.5	30.5	37.8	28.0	23.2	33.2	30.6	32.7
Ba	1306	1399	1326	1292	1378	1272	1391	1401	1378	1353	1354	1418	1408	1411
Or	11.40	10.72	9.89	11.00	11.11	11.16	10.97	11.00	11.18	10.76	11.02	11.21	11.05	11.10
Ab	28.84	28.23	27.46	29.40	28.60	29.07	30.31	30.30	29.87	26.13	28.07	29.03	29.79	29.48
An	23.63	23.90	26.56	23.96	23.81	23.96	24.88	24.65	24.61	22.35	22.68	24.56	24.49	24.44
Ne	1.26	1.76	0.00	0.49	0.80	0.22	0.33	0.01	0.26	2.46	1.36	0.40	0.00	0.00
Di	8.67	8.83	6.38	9.77	9.45	9.74	7.72	7.64	8.29	10.69	9.33	8.33	8.16	8.32
Hy	0.00	0.00	11.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.41
Ol	16.48	16.79	8.63	15.97	16.12	15.68	16.77	17.09	16.41	14.92	16.12	16.46	16.58	16.47
Mt	2.60	2.61	2.48	2.57	2.54	2.54	2.54	2.55	2.53	2.51	2.58	2.54	2.55	2.55
Il	3.87	3.87	3.83	3.79	3.73	3.76	3.71	3.67	3.68	3.72	3.82	3.72	3.71	3.73
Ap	3.01	3.04	2.96	2.95	3.01	3.00	2.99	2.97	2.97	2.95	2.95	2.90	2.95	2.92

Appendix A
Major, trace-element (determined by XRF) and normative compositions of Lathrop Wells basalts

Sample	LW50FVP	LW51FVP	LW52FVP	LW98FVP	LW99FVP	LW103FVP	LW113FVP	LW116FVP	LW117FVP	LW06FVP	LW07FVP	LW40FVP	LW41FVP	LW55FVP
Unit	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u	Ql2a	Ql2a	Ql2a	Ql2a	Ql2a
SiO_2	48.50	48.71	48.60	48.94	48.89	48.91	49.02	48.37	47.92	48.58	48.89	49.74	48.78	48.71
TiO_2	1.95	1.97	1.95	1.97	1.99	1.97	2.01	1.98	1.97	1.90	1.89	1.89	1.89	1.84
Al_2O_3	16.62	16.87	16.75	16.84	16.92	16.60	16.96	16.81	16.49	16.92	17.10	17.06	16.87	16.76
Fe_2O_3T	11.58	11.58	11.73	11.75	11.81	11.84	11.88	11.81	11.57	11.45	11.50	11.38	11.48	11.43
Fe_2O_3	1.74	1.74	1.76	1.76	1.77	1.78	1.78	1.77	1.74	1.72	1.72	1.71	1.72	1.71
FeO	8.86	8.86	8.97	8.99	9.04	9.06	9.09	9.04	8.85	8.76	8.80	8.71	8.78	8.74
MnO	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
MgO	5.87	5.86	5.91	5.78	5.94	5.93	5.87	5.75	5.69	5.86	5.76	5.50	5.75	5.79
CaO	8.29	8.36	8.31	8.47	8.66	8.29	8.32	8.28	9.11	8.50	8.55	8.74	8.48	8.66
Na_2O	3.54	3.59	3.51	3.57	3.52	3.44	3.60	3.78	3.37	3.52	3.44	3.61	3.56	3.38
K_2O	1.85	1.89	1.94	1.92	1.89	1.94	1.90	(2.12)	1.77	1.78	1.83	1.87	1.82	1.86
P_2O_5	1.20	1.22	1.22	1.23	1.25	1.22	1.23	1.25	1.21	1.21	1.23	1.21	1.23	1.20
Total	99.56	100.22	100.09	100.63	101.05	100.31	100.96	100.31	99.26	99.90	100.36	101.18	100.03	99.80
Mg#	54.13	54.09	53.98	53.39	53.96	53.83	53.53	53.14	53.38	54.37	53.86	52.97	53.85	54.13
V	179.1	171.3	186.3	193.1	177.7	173.1	160.3	170.8	172.3	181.1	168.9	179.7	184.2	177.1
Cr	120.1	118.6	136.9	102.6	121.5	109.8	123.8	119.7	150.6	128.7	109.1	93.3	106.4	112.8
Ni	56.7	57.2	59.2	57.7	58.5	57.5	54.3	57.5	55.2	51.8	50.1	40.5	48.4	46.6
Zn	137.1	139.7	130.6	138.7	147.2	138.0	130.4	132.6	138.5	124.2	128.3	141.6	133.4	128.9
Rb	18.0	21.0	17.1	19.4	17.9	20.5	17.2	18.7	15.8	17.2	17.5	19.6	17.2	22.9
Sr	1474	1502	1481	1512	1514	1498	1523	1529	1530	1418	1444	1451	1447	1438
Y	16.5	26.5	31.8	29.8	35.4	27.1	27.5	28.5	35.6	25.0	24.1	22.7	30.0	27.1
Zr	369.9	357.7	373.0	376.6	384.7	377.6	391.0	369.4	373.5	375.1	362.9	367.7	374.3	366.3
Nb	30.8	33.5	28.0	32.4	32.6	26.1	31.3	33.0	30.2	25.6	29.4	31.7	25.6	27.2
Ba	1444	1396	1464	1290	1317	1328	1318	1248	1256	1384	1413	1359	1374	1374
Or	10.94	11.20	11.46	11.36	11.19	11.46	11.25	(12.53)	10.47	10.52	10.83	11.07	10.74	11.01
Ab	29.91	29.83	29.55	29.90	29.21	29.12	30.36	(27.27)	27.62	29.80	29.06	30.53	30.10	28.62
An	24.12	24.43	24.34	24.37	24.87	24.23	24.63	(22.73)	24.73	25.21	25.94	24.93	24.81	25.15
Ne	0.00	0.30	0.07	0.15	0.32	0.00	0.03	(2.56)	0.49	0.00	0.00	0.00	0.00	0.00
Di	8.24	8.21	8.11	8.66	8.94	8.09	7.84	(9.11)	11.05	8.16	7.70	9.39	8.37	8.97
Hy	0.50	0.00	0.00	0.00	0.00	2.44	0.00	(0.00)	0.00	0.56	2.58	1.42	0.62	1.92
Ol	16.12	16.47	16.76	16.33	16.55	15.09	16.86	(16.15)	15.13	16.03	14.60	14.26	15.76	14.67
Mt	2.52	2.52	2.55	2.55	2.57	2.57	2.58	(2.57)	2.52	2.49	2.50	2.47	2.50	2.48
Il	3.71	3.74	3.71	3.74	3.78	3.75	3.82	(3.77)	3.74	3.61	3.60	3.59	3.59	3.50
Ap	2.89	2.92	2.92	2.93	2.98	2.92	2.93	(2.98)	2.90	2.91	2.94	2.90	2.93	2.86

Appendix A

Major, trace-element (determined by XRF) and normative compositions of Lathrop Wells basalts

Sample	LW56FVP	LW19FVP	LW25FVP	LW26FVP	LW27FVP	LW28FVP	LW29FVP	LW04FVPA	LW54FVP	LW57FVP	LW58FVP	LW39FVP	LW48FVP	LW44FVP
Unit	Ql2a	Ql2a	Ql2b	Ql2b	Ql2b	Ql2b	Ql2b	Ql2c	Ql2c	Ql2c	Ql2c	Ql2u	Ql2u	Qs2a
SiO_2	48.30	48.96	48.26	48.26	48.87	48.62	48.66	49.04	48.41	48.79	48.53	48.20	48.28	47.49
TiO_2	1.90	1.86	1.93	1.93	1.96	1.86	1.97	1.85	1.87	1.85	1.91	1.91	1.91	1.88
Al_2O_3	16.65	16.69	16.96	16.68	16.78	16.74	16.73	16.73	16.77	16.80	16.39	16.68	16.67	16.23
Fe_2O_3T	11.56	11.40	11.90	11.56	11.74	11.40	11.72	11.47	11.40	11.55	11.39	11.46	11.39	11.43
Fe_2O_3	1.73	1.71	1.78	1.73	1.76	1.71	1.76	1.72	1.71	1.73	1.71	1.72	1.71	1.71
FeO	8.84	8.72	9.10	8.84	8.98	8.72	8.97	8.78	8.72	8.84	8.71	8.77	8.71	8.74
MnO	0.17	0.18	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.17	0.17	0.17	0.17
MgO	5.88	5.79	5.81	5.83	5.88	5.86	5.89	5.75	5.78	5.68	5.84	5.88	5.85	5.86
CaO	8.77	8.61	8.38	8.62	8.51	8.67	8.38	8.94	8.72	8.92	8.80	8.41	8.64	8.36
Na_2O	3.52	3.43	3.54	3.47	3.60	3.44	3.61	3.40	3.44	3.47	3.55	3.60	3.53	3.42
K_2O	1.84	1.79	1.86	1.80	1.85	1.81	1.83	1.83	1.78	1.76	1.79	1.86	1.86	1.80
P_2O_5	1.18	1.25	1.23	1.19	1.21	1.21	1.22	1.21	1.18	1.23	1.20	1.18	1.20	1.17
Total	99.77	99.94	100.03	99.50	100.57	99.77	100.18	100.40	99.52	100.22	99.56	99.35	99.50	97.81
Mg#	54.24	54.18	53.19	54.01	53.84	54.47	53.91	53.88	54.15	53.40	54.43	54.45	54.46	54.44
V	173.9	176.7	175.3	182.0	172.4	181.8	172.1	179.5	175.2	177.4	169.5	170.6	186.1	180.7
Cr	110.8	99.5	116.4	127.5	113.0	110.0	115.6	112.4	94.4	103.7	104.6	109.8	124.2	117.5
Ni	54.0	56.5	63.3	60.2	58.3	49.4	53.6	50.4	42.9	49.9	50.8	56.8	53.0	53.7
Zn	126.0	127.0	127.3	125.4	128.3	126.8	119.4	135.9	129.9	115.8	129.6	127.1	133.2	135.1
Rb	18.6	18.7	18.3	18.6	15.8	17.0	18.3	20.3	21.0	19.8	17.6	20.8	18.2	17.7
Sr	1449	1451	1456	1453	1489	1426	1496	1454	1450	1423	1486	1455	1467	1394
Y	29.1	24.7	32.4	24.3	25.0	27.9	31.9	28.0	30.6	23.7	29.8	21.9	27.2	30.9
Zr	367.6	382.4	378.7	386.4	377.5	367.0	372.1	374.7	379.1	370.7	368.7	366.9	379.3	369.9
Nb	28.6	30.8	39.4	25.2	32.0	32.9	33.4	32.4	22.7	27.5	29.1	30.7	23.9	25.5
Ba	1407	1393	1450	1403	1399	1395	1392	1322	1377	1410	1312	1455	1435	1391
Or	10.90	10.57	10.97	10.66	10.92	10.72	10.84	10.84	10.53	10.40	10.57	10.98	11.02	10.64
Ab	27.98	28.99	29.07	29.02	29.88	29.07	30.01	28.77	29.12	29.36	29.14	28.70	28.49	28.67
An	24.27	24.99	25.02	24.73	24.26	25.00	24.12	25.07	25.15	25.17	23.61	23.96	24.26	23.74
Ne	0.99	0.00	0.48	0.17	0.33	0.00	0.30	0.00	0.00	0.00	0.47	0.97	0.72	0.12
Di	10.21	8.61	7.77	9.20	8.98	9.05	8.53	10.10	9.28	9.85	10.79	9.03	9.58	9.00
Hy	0.00	3.84	0.00	0.00	0.00	1.11	0.00	1.75	0.30	0.65	0.00	0.00	0.00	0.00
Ol	15.85	13.34	16.89	16.09	16.38	15.31	16.54	14.35	15.68	15.22	15.40	16.17	15.84	16.16
Mt	2.51	2.48	2.59	2.51	2.55	2.48	2.55	2.49	2.48	2.51	2.48	2.49	2.48	2.48
Il	3.61	3.54	3.67	3.66	3.73	3.53	3.74	3.52	3.55	3.51	3.62	3.63	3.63	3.57
Ap	2.82	2.98	2.94	2.84	2.91	2.89	2.93	2.89	2.82	2.94	2.86	2.82	2.88	2.81

Appendix A
Major, trace-element (determined by XRF) and normative compositions of Lathrop Wells basalts

Sample	LW96FVP	LW97FVP	LW104FVP	LW119FVP	LW126FVP	LW130FVP	LW132FVP	LW135FVP	LW114FVP	LW118FVP	LW127FVP	LW128FVP	LW36FVP	LW37FVP
Unit	Qs2fs	Qs2fs	Qs2fs	Qs2fs	Qs2fs	Qs2fs	Qs2fs	Qs2fs	Qs2fs	Qs2fs	Qs2fs	Qs2fs	Qs2u	Qs2u
SiO_2	48.84	49.32	49.30	49.22	49.01	49.04	49.46	49.22	48.87	49.50	49.17	49.12	48.61	48.82
TiO_2	1.93	1.91	1.94	1.87	1.92	1.93	1.89	1.94	1.92	1.90	1.95	1.94	1.92	1.91
Al_2O_3	16.71	16.80	16.91	16.87	17.02	16.95	16.91	16.80	17.00	17.18	17.02	16.87	16.89	16.60
Fe_2O_3T	11.63	11.76	11.61	11.53	11.76	11.82	11.66	11.54	11.62	11.48	11.74	11.58	11.63	11.63
Fe_2O_3	1.74	1.76	1.74	1.73	1.76	1.77	1.75	1.73	1.74	1.72	1.76	1.74	1.74	1.74
FeO	8.90	9.00	8.88	8.82	9.00	9.04	8.92	8.83	8.89	8.78	8.98	8.86	8.90	8.90
MnO	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.17	0.18	0.17
MgO	5.92	6.13	5.85	5.90	5.75	5.87	5.89	5.78	5.94	5.81	5.99	5.74	5.81	5.84
CaO	8.56	8.38	8.33	8.70	8.40	8.39	8.46	8.26	8.39	8.54	8.14	8.12	8.45	8.34
Na_2O	3.48	3.32	3.37	3.32	3.04	3.27	3.28	3.27	3.45	3.45	3.46	3.60	3.43	3.48
K_2O	1.82	1.83	1.79	1.79	1.71	1.73	1.82	1.89	1.86	1.89	1.89	(2.24)	1.88	1.89
P_2O_5	1.27	1.22	1.19	1.23	1.14	1.16	1.19	1.15	1.18	1.19	1.19	1.19	1.23	1.19
Total	100.32	100.84	100.46	100.59	99.93	100.33	100.74	100.01	100.39	101.10	100.71	100.56	100.03	99.87
Mg#	54.26	54.85	53.99	54.36	53.23	53.62	54.07	53.84	54.35	54.09	54.29	53.59	53.80	53.93
V	179.7	178.8	181.1	177.0	175.9	179.0	179.3	166.9	175.5	183.3	178.8	180.9	178.0	186.7
Cr	110.5	126.5	118.2	104.1	106.4	116.6	113.2	110.8	122.1	109.5	110.0	111.7	132.8	123.7
Ni	51.2	54.1	57.5	49.9	50.4	53.9	53.4	48.6	47.5	47.0	58.0	58.3	54.6	57.4
Zn	135.5	141.7	129.6	135.6	141.6	137.5	141.2	136.2	134.1	136.8	140.5	138.4	124.9	126.5
Rb	20.0	17.5	19.7	19.1	16.7	19.8	22.8	19.9	19.0	21.6	21.1	26.1	18.9	19.9
Sr	1454	1465	1479	1429	1616	1528	1464	1476	1442	1449	1482	1469	1447	1456
Y	26.4	32.4	32.8	26.8	33.7	28.5	30.5	28.1	25.8	29.3	30.6	26.2	21.3	26.1
Zr	368.7	358.7	366.4	368.5	377.6	377.2	364.9	367.9	366.9	364.4	387.5	371.5	368.0	371.0
Nb	33.0	33.8	34.5	31.6	33.7	37.0	32.5	36.9	33.6	28.8	28.1	27.1	34.2	33.9
Ba	1373	1308	1329	1353	1307	1268	1340	1376	1312	1331	1343	1353	1388	1406
Or	10.78	10.79	10.58	10.56	10.14	10.20	10.79	11.18	10.98	11.17	11.17	(13.24)	11.11	11.16
Ab	29.45	28.07	28.51	28.06	25.72	27.69	27.77	27.62	29.15	29.18	29.25	(28.94)	29.01	29.44
An	24.69	25.66	25.84	25.97	27.85	26.57	26.13	25.71	25.54	25.93	25.46	(23.38)	25.25	24.21
Ne	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(0.81)	0.00	0.00
Di	8.53	7.23	7.07	8.24	6.00	6.88	7.34	7.14	7.62	7.88	6.57	(8.24)	7.84	8.46
Hy	1.74	6.64	6.92	5.73	12.55	7.79	7.82	7.84	2.08	3.39	3.93	(0.00)	1.62	1.86
Ol	15.29	12.68	11.85	12.41	8.09	11.53	11.28	10.97	15.39	14.00	14.59	(16.29)	15.45	15.11
Mt	2.53	2.56	2.52	2.51	2.56	2.57	2.54	2.51	2.53	2.50	2.55	(2.52)	2.53	2.53
Il	3.66	3.63	3.68	3.54	3.65	3.66	3.59	3.67	3.65	3.60	3.70	(3.68)	3.65	3.62
Ap	3.03	2.92	2.86	2.95	2.74	2.79	2.85	2.75	2.81	2.84	2.86	(2.85)	2.94	2.86

Appendix A

Major, trace-element (determined by XRF) and normative compositions of Lathrop Wells basalts

Sample	LW38FVP	LW05FVPA	LW59FVP	LW60FVP	LW61FVP	LW62FVP	LW02FVP	LW03FVP	LW68FVP	LW69FVP	LW70FVP	LW75FVP	LW76FVP	LW80FVP
Unit	Qs2u	Ql3	Ql3	Ql3	Ql3	Ql3	Qs3	Qs3	Qs3	Qs3	Qs3	Qs3	Qs3	Qs3
SiO_2	48.77	49.31	49.03	48.88	48.65	48.19	48.55	48.68	48.62	49.02	48.74	48.67	48.46	48.50
TiO_2	1.94	1.91	1.86	1.84	1.83	1.82	1.83	1.83	1.90	1.87	1.87	1.90	1.89	1.91
Al_2O_3	16.45	16.76	16.95	16.75	16.87	16.87	16.96	16.87	16.86	16.96	16.81	16.86	16.94	16.73
Fe_2O_3T	11.69	11.59	11.42	11.37	11.45	11.22	11.25	11.50	11.45	11.43	11.40	11.57	11.66	11.48
Fe_2O_3	1.75	1.74	1.71	1.71	1.72	1.68	1.69	1.72	1.72	1.71	1.71	1.74	1.75	1.72
FeO	8.94	8.87	8.74	8.70	8.76	8.58	8.61	8.80	8.76	8.74	8.72	8.85	8.92	8.78
MnO	0.17	0.17	0.18	0.17	0.18	0.17	0.17	0.18	0.17	0.17	0.17	0.17	0.17	0.17
MgO	5.86	5.95	5.60	5.76	5.70	5.62	5.22	5.67	5.90	5.69	5.77	5.72	5.74	5.78
CaO	8.32	8.84	8.64	8.74	8.79	8.93	8.83	8.52	8.59	8.65	8.70	8.20	8.30	8.62
Na_2O	3.58	3.53	3.43	3.41	3.39	3.31	3.47	3.35	3.50	3.43	3.44	3.22	2.99	3.47
K_2O	1.94	1.83	1.88	1.84	1.80	1.81	1.77	1.76	1.84	1.78	1.80	1.76	1.72	1.76
P_2O_5	1.21	1.19	1.23	1.17	1.17	1.19	1.21	1.18	1.21	1.19	1.19	1.17	1.12	1.20
Total	99.91	101.07	100.22	99.93	99.82	99.15	99.25	99.53	100.04	100.19	99.89	99.24	98.99	99.62
Mg#	53.86	54.46	53.30	54.15	53.72	53.87	51.93	53.44	54.54	53.69	54.11	53.54	53.43	53.99
V	186.5	181.6	185.6	182.0	187.6	175.5	181.4	178.4	179.9	180.2	181.1	181.3	164.0	168.4
Cr	134.8	112.5	86.8	95.0	110.3	108.3	63.1	107.3	111.7	105.0	105.3	106.6	96.9	107.4
Ni	55.9	52.3	46.8	44.8	46.9	47.4	32.5	42.2	45.3	45.3	48.1	55.0	58.1	50.2
Zn	124.5	127.8	130.9	139.3	137.6	131.8	124.9	132.1	133.9	133.0	128.2	115.9	135.0	141.3
Rb	19.7	20.9	18.0	19.3	19.8	23.9	21.7	18.3	19.5	20.2	19.7	20.8	19.9	20.3
Sr	1484	1486	1425	1448	1450	1443	1470	1431	1480	1430	1440	1444	1476	1450
Y	28.5	26.2	29.4	21.5	22.6	22.2	34.2	28.8	26.1	26.5	25.9	26.7	23.9	18.3
Zr	365.3	356.4	377.6	360.4	370.5	368.1	370.8	372.5	372.4	371.8	363.9	370.8	372.0	366.6
Nb	32.2	26.8	32.0	31.0	36.6	27.1	26.9	29.9	31.0	29.9	30.1	35.5	32.4	36.5
Ba	1433	1280	1426	1395	1376	1385	1433	1419	1361	1410	1404	1412	1362	1426
Or	11.50	10.80	11.12	10.86	10.63	10.72	10.45	10.42	10.90	10.53	10.66	10.40	10.15	10.41
Ab	29.87	29.88	29.05	28.83	28.65	28.03	29.39	28.31	29.41	29.03	29.08	27.24	25.27	29.32
An	23.19	24.58	25.39	25.09	25.63	25.91	25.57	25.92	24.94	25.73	25.22	26.48	27.87	25.00
Ne	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00
Di	9.14	10.16	8.50	9.46	9.21	9.47	9.29	7.89	8.77	8.51	9.12	6.13	5.67	8.89
Hy	0.00	0.06	2.63	1.92	1.63	0.89	1.38	4.67	0.00	3.28	1.49	8.99	12.15	1.21
Ol	16.28	15.97	13.95	14.40	14.69	14.77	13.78	12.91	16.29	13.64	14.84	10.47	8.44	15.18
Mt	2.54	2.52	2.48	2.47	2.49	2.44	2.45	2.50	2.49	2.48	2.48	2.52	2.54	2.50
Il	3.67	3.62	3.53	3.50	3.48	3.46	3.48	3.48	3.61	3.54	3.55	3.60	3.59	3.62
Ap	2.89	2.85	2.95	2.81	2.81	2.85	2.89	2.81	2.89	2.84	2.84	2.80	2.69	2.88

Appendix A

Major, trace-element (determined by XRF) and normative compositions of Lathrop Wells basalts

Sample	LW81FVP	LW82FVP-B	LW82FVP-R	LW86FVP	LW87FVP	LW88FVP	LW95FVP	LW123FVP	LW133FVP-B	LW133FVP-R	LW78FVP-B	LW78FVP-R
Unit	Qs3	Qs3	Qs3	Qs3	Qs3	Qs3	Qs3	Qs3	Qs4a	Qs4a	Qs4b	Qs4b
SiO_2	48.78	49.09	48.04	49.62	49.33	49.43	48.98	49.04	49.36	48.90	49.77	49.34
TiO_2	1.85	1.83	1.85	1.86	1.86	1.85	1.90	1.89	1.87	1.82	1.75	1.75
Al_2O_3	16.84	16.91	16.51	17.08	16.95	16.84	17.08	16.79	16.70	16.45	16.63	16.68
Fe_2O_3T	11.52	11.34	11.43	11.49	11.50	11.50	11.80	11.60	11.81	11.90	10.87	10.98
Fe_2O_3	1.73	1.70	1.71	1.72	1.72	1.72	1.77	1.74	1.77	1.78	1.63	1.65
FeO	8.81	8.68	8.74	8.79	8.80	8.80	9.03	8.87	9.04	9.10	8.32	8.40
MnO	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.18	0.18	0.17	0.17	0.17
MgO	5.88	5.64	5.65	5.69	5.59	5.71	5.86	5.99	6.21	6.32	5.63	5.36
CaO	8.57	8.59	8.67	8.81	8.94	8.86	8.66	8.44	8.57	8.43	8.40	8.29
Na_2O	3.39	3.28	3.50	3.09	3.19	3.32	3.15	3.52	3.20	3.49	3.05	3.13
K_2O	1.71	1.75	(1.43)	1.72	1.73	1.77	(1.48)	(1.61)	1.79	(1.74)	1.91	(1.77)
P_2O_5	1.19	1.18	1.19	1.21	1.21	1.20	1.24	1.16	1.20	1.18	1.18	1.33
Total	99.90	99.77	98.45	100.74	100.47	100.64	100.32	100.21	100.89	100.40	99.37	98.81
Mg#	54.34	53.69	53.53	53.57	53.12	53.63	53.66	54.61	55.07	55.30	54.70	53.23
V	174.7	181.0	172.8	182.4	187.5	193.1	181.0	174.4	167.9	181.4	164.1	160.4
Cr	106.9	84.0	111.5	102.8	97.9	105.2	106.3	113.0	297.0	406.1	103.2	102.2
Ni	49.9	45.3	54.3	48.0	40.7	49.4	46.4	55.9	62.5	76.8	53.0	47.8
Zn	138.0	124.0	133.3	134.2	136.5	127.7	142.0	133.5	137.9	144.1	134.5	145.9
Rb	20.1	18.2	14.5	20.5	17.9	18.7	19.0	22.6	20.6	17.9	30.7	32.5
Sr	1412	1439	1426	1460	1449	1449	1498	1420	1432	1427	1317	1318
Y	22.3	26.5	25.2	29.9	27.9	25.2	30.8	24.3	25.4	26.7	32.0	32.0
Zr	367.6	379.8	371.3	363.6	371.0	367.4	374.0	366.3	362.2	360.2	361.0	363.1
Nb	30.6	30.1	31.5	32.6	33.1	30.4	27.7	36.4	31.8	32.0	31.4	32.8
Ba	1417	1429	1406	1334	1357	1284	1324	1301	1344	1259	1330	1292
Or	10.13	10.32	(8.45)	10.16	10.25	10.47	(8.73)	(9.53)	10.59	(10.26)	11.32	(10.48)
Ab	28.68	27.77	(29.62)	26.16	27.02	28.06	(26.62)	(29.76)	27.09	(29.53)	25.76	(26.46)
An	25.78	26.37	(25.22)	27.76	26.90	25.94	(28.24)	(25.37)	26.01	(24.19)	26.16	(26.35)
Ne	0.00	0.00	(0.00)	0.00	0.00	0.00	(0.00)	(0.00)	0.00	(0.00)	0.00	(0.00)
Di	8.10	7.77	(8.96)	7.33	8.59	9.10	(6.23)	(8.04)	7.86	(8.88)	7.10	(5.67)
Hy	4.07	7.53	(3.37)	12.20	8.48	6.09	(12.16)	(4.14)	7.98	(1.78)	14.51	(15.66)
Ol	13.66	10.66	(13.36)	7.59	9.70	11.49	(8.57)	(13.86)	11.72	(16.21)	5.42	(4.71)
Mt	2.51	2.47	(2.48)	2.50	2.50	2.50	(2.57)	(2.52)	2.57	(2.59)	2.36	(2.39)
Il	3.51	3.48	(3.52)	3.53	3.53	3.50	(3.61)	(3.59)	3.56	(3.46)	3.33	(3.32)
Ap	2.84	2.82	(2.86)	2.90	2.89	2.87	(2.96)	(2.78)	2.86	(2.82)	2.83	(3.19)

Appendix A

Major, trace-element (determined by XRF) and normative compositions of Lathrop Wells basalts

Sample	LW124FVP-B	LW124FVP-R	LW134FVP	LW15FVP	LW16FVP	LW14FVP	LW129FVP	LW131FVP-B
Unit	Qs4b	Qs4b	Qs4b	Qs4c	Qs4c	?	?	?
SiO_2	50.37	49.46	50.11	48.20	48.65	49.13	49.06	49.13
TiO_2	1.79	1.81	1.81	1.81	1.80	1.88	2.02	1.84
Al_2O_3	16.88	16.85	16.79	16.07	16.24	16.82	16.79	16.79
Fe_2O_3T	11.09	11.21	11.21	12.05	12.13	11.61	11.93	11.40
Fe_2O_3	1.66	1.68	1.68	1.81	1.82	1.74	1.79	1.71
FeO	8.48	8.58	8.58	9.22	9.28	8.88	9.13	8.72
MnO	0.16	0.18	0.19	0.18	0.18	0.17	0.18	0.18
MgO	5.62	5.13	5.70	7.09	7.14	5.71	5.89	5.73
CaO	8.08	8.11	7.98	8.20	8.18	7.98	7.84	8.41
Na_2O	3.47	3.66	3.08	3.18	3.17	3.06	3.32	3.47
K_2O	1.87	(1.55)	1.93	1.64	1.63	1.67	1.96	1.86
P_2O_5	1.17	1.26	1.26	1.17	1.18	1.07	1.21	1.23
Total	100.51	99.21	100.04	99.57	100.30	99.09	100.19	100.05
Mg#	54.16	51.60	54.23	57.80	57.82	53.41	53.49	53.95
V	165.9	169.1	163.5	171.7	169.4	161.5	180.9	181.2
Cr	110.3	106.9	128.0	187.0	193.0	106.2	108.2	107.2
Ni	48.8	39.4	52.0	110.4	106.5	57.8	51.5	47.6
Zn	134.3	184.0	140.5	94.3	99.0	100.8	138.7	136.2
Rb	30.8	28.6	32.6	16.8	15.8	16.5	19.6	22.8
Sr	1334	1349	1334	1372	1380	1414	1503	1398
Y	30.5	27.6	28.1	17.6	25.4	32.0	25.7	27.5
Zr	357.9	364.2	372.2	352.3	357.1	368.2	382.0	369.6
Nb	33.2	38.7	30.8	31.0	26.6	29.9	37.3	27.7
Ba	1347	1282	1251	1334	1317	1383	1298	1320
Or	11.08	(9.17)	11.40	9.68	9.62	9.86	11.58	11.03
Ab	29.35	(30.92)	26.03	26.87	26.85	25.90	28.11	29.36
An	25.06	(25.09)	26.42	24.86	25.37	27.35	25.23	24.83
Ne	0.00	(0.00)	0.00	0.00	0.00	0.00	0.00	0.00
Di	6.76	(6.39)	4.71	7.41	6.84	5.04	5.45	8.01
Hy	10.27	(9.28)	17.51	6.05	7.72	15.65	7.65	3.68
Ol	8.78	(8.85)	4.47	15.17	14.34	6.02	12.20	13.61
Mt	2.41	(2.44)	2.44	2.62	2.64	2.52	2.59	2.48
Il	3.40	(3.44)	3.43	3.44	3.42	3.56	3.83	3.50
Ap	2.80	(3.01)	3.02	2.80	2.83	2.56	2.90	2.94

Appendix B

B:1 Trace-element compositions of Lathrop Wells basalts determined by INAA

Sample	LW11FVP	LW12FVP	LW74FVP	LW45FVP	LW72FVP	LW73FVP	LW100FVP	LW101FVP	LW30FVP	LW31FVP	LW32FVP
Unit	Ql1a	Ql1a	Ql1a	Ql1b	Ql1b	Ql1b	Ql1b	Qs1b	Ql1c	Ql1c	Ql1c
Rb	20	21	22	21	18	19	19	20	22	21	18
Sc	18.8	18.9	18.87	19.1	18.7	19	19.04	18.7	18.8	19	18.9
Co	30.8	31.1	30.6	31	30.5	30.5	30.7	30.4	29.8	30.2	30.6
Sr	1430	1440	1420	1480	1400	1460	1470	1460	1470	1410	1390
Ba	1410	1420	1430	1380	1370	1430	1430	1420	1410	1430	1450
La	92.1	92.3	92.5	94.2	92.7	93.7	94.4	92.2	90.5	92	92.9
Ce	180	181	181	185	183	186.5	185.8	181.6	177	179	181
Nd	72	74	80	78	72	80	84	76	72	71	80
Sm	12.5	12.2	12.38	12.6	12.6	12.67	12.86	12.51	11.9	12.1	12.4
Eu	3.19	3.17	3.15	3.28	3.29	3.27	3.32	3.18	3.07	3.09	3.16
Tb	1.15	1.13	1.13	1.16	1.13	1.18	1.2	1.18	1.09	1.09	1.13
Yb	2.36	2.3	2.29	2.42	2.39	2.38	2.34	2.29	2.24	2.28	2.35
Lu	0.333	0.318	0.339	0.336	0.334	0.352	0.337	0.337	0.341	0.353	0.338
Hf	7.22	7.34	7.21	7.27	7.24	7.35	7.35	7.12	6.91	7	7.29
Ta	1.40	1.37	1.40	1.37	1.39	1.43	1.43	1.42	1.32	1.34	1.37
Th	6.51	6.64	6.59	6.33	6.27	6.48	6.43	6.27	6.65	6.84	6.56

Appendix B

B:1 Trace-element compositions of Lathrop Wells basalts determined by INAA

Sample	LW63FVP	LW64FVP	LW65FVP	LW66FVP	LW67FVP	LW110FVP	LW115FVP	LW93FVP	LW20FVP	LW21FVP	LW22FVP	LW23FVP
Unit	Ql1c	Ql1c	Ql1c	Ql1c	Ql1c	Ql1c	Ql1c	Qs1c	Ql1d	Ql1d	Ql1d	Ql1d
Rb	22.1	23	20.2	22	21	22	26	20	22	19.3	19	20
Sc	19.4	19.11	19.13	19.46	19.42	19.52	19.66	19.01	18.6	18.3	18.7	18.4
Co	31.56	30.27	30.58	30.58	31.32	30.8	31.2	30.74	30.3	30.4	31.5	30.9
Sr	1410	1450	1490	1450	1420	1420	1450	1410	1460	1520	1500	1490
Ba	1430	1430	1460	1450	1450	1510	1500	1470	1370	1320	1350	1330
La	93.2	92.6	93.3	93.8	93.3	93.5	94.2	92.8	91.9	90.3	92.6	91.7
Ce	182.4	180.2	183.4	182.6	182	183	181.8	181.3	183	181	184	183
Nd	74	74	75	73	74	79	78	75	77	78	73	81
Sm	12.23	12.2	12.5	12.43	12.24	12.39	12.26	12.29	12.5	12.4	12.7	12.5
Eu	3.16	3.11	3.21	3.17	3.14	3.17	3.16	3.11	3.23	3.24	3.28	3.28
Tb	1.11	1.13	1.181	1.15	1.14	1.15	1.18	1.19	1.14	1.14	1.17	1.15
Yb	2.37	2.39	2.36	2.4	2.42	2.33	2.37	2.37	2.36	2.34	2.42	2.27
Lu	0.345	0.338	0.334	0.343	0.35	0.338	0.341	0.346	0.332	0.306	0.356	0.368
Hf	7.31	7.27	7.28	7.36	7.24	7.19	7.36	7.34	7.26	7.04	7.17	7.16
Ta	1.34	1.35	1.38	1.39	1.36	1.39	1.36	1.39	1.36	1.37	1.39	1.39
Th	6.82	6.73	6.69	6.84	6.77	6.84	6.73	6.59	6.17	5.94	6.05	5.97

Appendix B

B:1 Trace-element compositions of Lathrop Wells basalts determined by INAA

Sample	LW79FVP	LW01FVP	LW71FVP	LW8FVP	LW9FVP	LW10FVP	LW33FVP	LW34FVP	LW35FVP	LW42FVP	LW43FVP	LW46FVP
Unit	Qs1d	Qs1r	Qs1r	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u	Qs1u
Rb	20	22	20	23	21	20	20	21	20	19	21	21
Sc	18.68	19.1	19	19.27	19.13	18.67	19.5	19.5	19.3	18.2	18.5	18.86
Co	31.3	30.7	31	31.2	30.9	30.3	30.6	31.8	30.8	29.4	30.6	30.31
Sr	1490	1420	1420	1540	1450	1470	1400	1390	1350	1430	1410	1430
Ba	1360	1430	1400	1430	1430	1400	1420	1460	1420	1340	1360	1430
La	92.6	93.1	94.6	95.2	94	92.1	94.1	94.3	94.4	90.3	91.5	92.3
Ce	184.4	183	187	184.9	185.4	178.4	183	184	182	179	183	181.1
Nd	78	74	73	79	76	80	77	70	73	79	79	76
Sm	12.77	12.5	12.9	12.64	12.55	12.29	12.4	12.3	12.4	12.1	12.6	12.32
Eu	3.26	3.18	3.31	3.28	3.22	3.17	3.18	3.22	3.18	3.17	3.25	3.12
Tb	1.19	1.14	1.16	1.18	1.19	1.15	1.1	1.12	1.1	1.1	1.17	1.13
Yb	2.42	2.36	2.47	2.32	2.32	2.29	2.4	2.37	2.33	2.4	2.38	2.35
Lu	0.338	0.346	0.354	0.328	0.331	0.339	0.354	0.366	0.367	0.313	0.343	0.336
Hf	7.29	7.35	7.29	7.31	7.23	7.11	7.24	7.26	7.06	6.96	7.22	7.29
Ta	1.38	1.36	1.43	1.42	1.40	1.39	1.35	1.39	1.37	1.34	1.38	1.37
Th	6.34	6.64	6.12	6.59	6.49	6.46	6.71	6.73	6.65	6.24	6.11	6.67

Appendix B

B:1 Trace-element compositions of Lathrop Wells basalts determined by INAA

Sample	LW47FVP	LW49FVP	LW50FVP	LW51FVP	LW98FVP	LW99FVP	LW103FVP	LW113FVP	LW116FVP	LW112FVP	LW06FVP
Unit	Qslu	Qslu	Qslu	Qslu	Qslu	Qslu	Qslu	Qslu	Qslu	Ql1u	Ql2a
Rb	22	20	19.1	22	21	18	22	23	19	18	19
Sc	19.31	19	19.02	19.1	19.28	19.41	19.05	19.12	19.09	18.9	19.4
Co	31.05	31.1	30.53	30.8	31	31.1	30.73	30.9	31.3	32.9	30.6
Sr	1400	1430	1440	1430	1460	1430	1460	1470	1440	1490	1310
Ba	1450	1420	1440	1450	1470	1450	1450	1420	1420	1460	1460
La	93.6	92.3	92.8	92.8	94.7	95.9	93.7	94.1	94.3	93.3	92
Ce	183.7	181	181.6	182	186.2	187.8	183.8	183.2	183.2	185.6	179
Nd	81	73	73	77	79	79	77	82	88	77	73
Sm	12.4	12.3	12.29	12.4	12.76	12.78	12.59	12.69	12.66	12.69	12
Eu	3.2	3.15	3.16	3.19	3.27	3.32	3.22	3.29	3.3	3.19	3.05
Tb	1.15	1.1	1.16	1.14	1.19	1.19	1.16	1.21	1.16	1.18	1.1
Yb	2.44	2.32	2.39	2.32	2.34	2.42	2.38	2.31	2.39	2.35	2.24
Lu	0.34	0.355	0.339	0.344	0.337	0.325	0.336	0.346	0.33	0.337	0.335
Hf	7.3	7.11	7.21	7.2	7.29	7.37	7.4	7.26	7.27	7.11	7.02
Ta	1.39	1.38	1.36	1.39	1.41	1.42	1.37	1.41	1.42	1.42	1.35
Th	6.86	6.55	6.6	6.68	6.59	6.65	6.66	6.55	6.54	6.38	6.89

Appendix B

B:1 Trace-element compositions of Lathrop Wells basalts determined by INAA

Sample	LW07FVP	LW19FVP	LW40FVP	LW41FVP	LW44FVP	LW25FVP	LW27FVP	LW28FVP	LW29FVP	LW96FVP	LW97FVP	LW104FVP
Unit	Ql2a	Ql2a	Ql2a	Ql2a	Ql2a	Ql2b	Ql2b	Ql2b	Ql2b	Qs2fs	Qs2fs	Qs2fs
Rb	22	23	23	21	20	21	21	22	21	21.6	20	22
Sc	19.9	20.1	19.75	19.8	19.3	19	19.3	19.7	19.3	19.29	19.37	19.15
Co	30.5	30.4	29.5	30.1	30.4	30.6	30.7	29.7	30.9	30.48	31.13	30.76
Sr	1310	1390	1403	1330	1400	1470	1450	1390	1370	1400	1380	1460
Ba	1440	1480	1450	1430	1390	1420	1400	1410	1400	1410	1400	1430
La	93.5	94.6	93.5	93.9	92	93.2	93.6	93.8	93.8	93.2	92.8	91.6
Ce	181	183.4	182.8	181	178	183	183	180	183	180.1	179.7	181.3
Nd	70	74	75	71	72	76	79	78	76	75	75	79
Sm	11.9	12.28	12.12	12.2	12	12.1	12.1	11.9	12.4	12	12.04	12.03
Eu	3.15	3.14	3.16	3.11	3.08	3.13	3.19	3.1	3.21	3.12	3.11	3.12
Tb	1.11	1.11	1.18	1.12	1.09	1.11	1.08	1.11	1.13	1.12	1.1	1.1
Yb	2.4	2.36	2.43	2.38	2.32	2.32	2.38	2.33	2.35	2.38	2.37	2.33
Lu	0.325	0.343	0.337	0.388	0.351	0.327	0.342	0.334	0.348	0.339	0.341	0.328
Hf	7.29	7.23	7.32	7.24	6.92	7.1	7.22	7.16	7.31	7.17	7.11	7.24
Ta	1.32	1.39	1.39	1.40	1.35	1.39	1.36	1.37	1.34	1.38	1.37	1.37
Th	6.98	7.15	7.06	6.9	6.84	6.59	6.51	7.12	6.61	6.86	6.84	6.83

Appendix B

B:1 Trace-element compositions of Lathrop Wells basalts determined by INAA

Sample	LW114FVP	LW118FVP	LW119FVP	LW126FVP	LW127FVP	LW130FVP	LW132FVP	LW135FVP	LW36FVP	LW37FVP
Unit	Qs2fs	Qs2fs	Qs2fs	Qs2fs	Qs2fs	Qs2fs	Qs2fs	Qs2fs	Qs2u	Qs2u
Rb	24	23	25	20	22	22	19	25	22	22
Sc	19.83	19.53	19.82	20.2	19.11	19.75	19.34	19.51	19.6	19.7
Co	31.2	30.2	30.4	30.7	30.6	31.4	30.8	30.7	30.9	31.1
Sr	1410	1380	1370	1530	1470	1400	1410	1410	1320	1310
Ba	1450	1410	1430	1460	1470	1420	1440	1490	1460	1430
La	94.2	93	94.1	95.2	92.1	93.7	91.2	92.6	94.2	95
Ce	179.8	177.7	177.3	185.7	180.6	179.1	175.4	183.7	184	185
Nd	80	75	81	76	74	82	75	78	72	72
Sm	12.28	12.06	12.01	12.24	12.12	12.12	11.98	12.19	12.2	12.3
Eu	3.15	3.1	3.12	3.18	3.12	3.15	3.01	3.17	3.16	3.18
Tb	1.13	1.1	1.14	1.16	1.15	1.14	1.12	1.17	1.11	1.11
Yb	2.38	2.28	2.43	2.39	2.24	2.33	2.29	2.33	2.36	2.35
Lu	0.333	0.334	0.34	0.333	0.349	0.323	0.329	0.318	0.352	0.344
Hf	7.22	7.18	7.14	7.24	7.13	7.16	7.03	7.23	7.28	7.34
Ta	1.39	1.37	1.41	1.41	1.40	1.40	1.39	1.39	1.37	1.36
Th	6.96	7.03	7.12	7.09	6.66	7	6.86	6.78	6.78	6.93

Appendix B

B:1 Trace-element compositions of Lathrop Wells basalts determined by INAA

Sample	LW38FVP	LW60FVP	LW61FVP	LW62FVP	LW02FVP	LW03FVP	LW69FVP	LW70FVP	LW75FVP	LW76FVP	LW80FVP	LW81FVP
Unit	Qs2u	Ql3	Ql3	Ql3	Qs3	Qs3	Qs3	Qs3	Qs3	Qs3	Qs3	Qs3
Rb	23	20.3	21	22	23	23	23	21	21.6	20.2	21	24
Sc	19.5	19.9	19.7	19.9	20.3	19.7	19.9	19.9	19.71	19.84	19.5	19.9
Co	31.2	30	29.8	29.9	28.1	30.3	29.4	30	30.62	30.66	30	30.3
Sr	1380	1330	1460	1330	1330	1340	1400	1390	1380	1410	1410	1370
Ba	1400	1410	1430	1380	1410	1410	1400	1420	1400	1400	1430	1420
La	94.1	94.4	94.1	94.6	97.1	93.3	94.6	95.1	93.8	93.2	93.2	94.7
Ce	184	181	179	180	186	178	182	182	180.5	181.1	178	182
Nd	71	65	74	71	77	68	80	72	75	75	78	76
Sm	12.3	12.1	12	12.1	12.2	12	12.1	12.1	12.06	11.94	11.8	12.2
Eu	3.22	3.1	3.06	3.12	3.16	3.06	3.11	3.12	3.06	3.11	3.1	3.12
Tb	1.14	1.11	1.1	1.1	1.13	1.07	1.11	1.09	1.14	1.17	1.1	1.11
Yb	2.37	2.35	2.34	2.38	2.36	2.43	2.38	2.29	2.37	2.36	2.28	2.33
Lu	0.331	0.359	0.338	0.346	0.36	0.339	0.361	0.344	0.341	0.353	0.37	0.357
Hf	7.2	7.14	7.12	7.21	7.41	7.22	7.15	7.22	7.29	7.2	6.98	7.13
Ta	1.34	1.38	1.37	1.37	1.38	1.40	1.37	1.37	1.39	1.37	1.36	1.37
Th	6.66	7.26	7.29	7.4	7.69	7.19	7.28	7.25	7.03	7.13	6.92	7.35

Appendix B

B:1 Trace-element compositions of Lathrop Wells basalts determined by INAA

Sample	LW82BFVP	LW82RFVP	LW86FVP	LW87FVP	LW88FVP	LW95FVP	LW123FVP	LW133FVP-R	LW133FVP-B	LW78FVP-B
Unit	Qs3	Qs3	Qs3	Qs3	Qs3	Qs3	Qs3	Qs4a	Qs4a	Qs4b
Rb	24	20	21	22.4	23	18	21	21	21	34
Sc	20.03	19.92	20.13	20.07	19.84	20.28	19.57	19.57	19.57	18.76
Co	29.77	30.54	29.83	29.68	29.68	30.65	30.6	32.8	32	28.88
Sr	1400	1370	1410	1430	1400	1460	1340	1390	1340	1290
Ba	1460	1420	1430	1431	1420	1390	1450	1410	1450	1360
La	95.6	94.8	96.1	96	94.6	96.6	92.6	92.2	92.2	91.7
Ce	183.9	181.9	184.4	184.9	182.4	186.3	178.8	182.8	179.5	175.9
Nd	75	74	70	74	72	77	77	74	80	73
Sm	11.94	12.18	12.26	12.22	12.06	12.4	11.89	11.95	11.95	11.8
Eu	3.11	3.14	3.1	3.15	3.09	3.19	3.05	3.07	3.07	2.91
Tb	1.12	1.15	1.15	1.13	1.15	1.14	1.16	1.11	1.11	1.12
Yb	2.39	2.39	2.41	2.44	2.45	2.48	2.33	2.48	2.3	2.54
Lu	0.348	0.349	0.36	0.351	0.349	0.348	0.334	0.35	0.349	0.38
Hf	7.41	7.37	7.43	7.31	7.23	7.35	7.05	7.15	7.13	7.4
Ta	1.39	1.36	1.39	1.35	1.34	1.39	1.40	1.41	1.39	1.38
Th	7.56	6.97	7.42	7.53	7.47	7.34	6.89	6.88	6.88	8.32

Appendix B

B:1 Trace-element compositions of Lathrop Wells basalts determined by INAA

Sample	LW78FVP-R	LW124FVP-B	LW124FVP-R	LW134FVP	LW15FVP	LW16FVP	LW14FVP
Unit	Qs4b	Qs4b	Qs4b	Qs4b	Qs4c	Qs4c	?
Rb	34.4	32	28	36	18	21	20
Sc	19.03	19.15	19.29	19.09	19.4	19.1	19.5
Co	28.89	28.9	28.7	29.5	36.5	35.8	30
Sr	1250	1300	1270	1260	1240	1230	1280
Ba	1330	1430	1380	1410	1350	1310	1390
La	96.2	91.1	93.7	96.4	90.3	89.7	90.3
Ce	179.6	176.2	179.1	188.6	174	172	178
Nd	75	71	73	75	67	66	68
Sm	12.57	11.91	12.13	12.56	11.4	11.3	11.2
Eu	3.07	2.96	2.96	3.15	3	2.94	2.99
Tb	1.23	1.16	1.16	1.23	1.06	1.04	1.03
Yb	2.8	2.48	2.49	2.89	2.23	2.18	2.23
Lu	0.405	0.35	0.399	0.403	0.333	0.314	0.334
Hf	7.35	7.38	7.2	7.69	6.94	6.87	7.22
Ta	1.38	1.38	1.42	1.47	1.28	1.27	1.30
Th	9.01	8.1	8.18	9.18	6.77	6.82	6.8

Appendix B
B:2 Replicate INAA analysis of LW27FVP

Sample	Sc	Co	Rb	Sr	Ba	La	Ce	Nd
LW27FVP[1]	19.3	30.7	21	1450	1400	93.6	183	79
NM18FVP[1]	19.4	31.1	18	1370	1430	93.9	183	71
NM19FVP[1]	19.2	30.7	23	1410	1430	92.8	181	73
NM20FVP[1]	19.3	30.8	19	1420	1440	93.3	183	78
NM30FVP[2]	19.23	30.81	21	1430	1430	93.4	183.4	77
NM33FVP[2]	19.2	30.64	20.3	1440	1430	92.9	183.8	78
NM34FVP[2]	19.24	30.66	21	1440	1460	93.1	182.7	77
NM41FVP[2]	19.15	30.66	21	1430	1440	92.6	182.5	77
NM42FVP[3]	19.13	30.6	20	1410	1470	92.8	181.3	77
NM43FVP[3]	19.44	31.2	20	1430	1500	94.2	183.7	78
NM45FVP[3]	19.36	30.7	17	1440	1480	93.8	183	75
NM48FVP[3]	19.42	31	18	1360	1470	93.7	183.7	73
Mean	19.28	30.80	19.94	1419.17	1448.33	93.34	182.84	76.08
Standard Deviation	0.11	0.20	1.68	28.11	27.91	0.51	0.89	2.50
Percent Standard Deviation (100·s/mean)	0.55	0.64	8.42	1.98	1.93	0.55	0.49	3.29

Sample	Sm	Eu	Tb	Yb	Lu	Hf	Ta	Th
LW27FVP[1]	12.1	3.19	1.08	2.38	0.340	7.22	1.36	6.51
NM18FVP[1]	12.4	3.19	1.13	2.35	0.350	7.22	1.38	6.65
NM19FVP[1]	12.4	3.16	1.14	2.33	0.360	7.23	1.4	6.68
NM20FVP[1]	12.4	3.19	1.13	2.25	0.360	7.14	1.37	6.56
NM30FVP[2]	12.33	3.17	1.12	2.39	0.332	7.37	1.36	6.71
NM33FVP[2]	12.36	3.19	1.14	2.41	0.340	7.36	1.37	6.77
NM34FVP[2]	12.47	3.19	1.16	2.39	0.342	7.27	1.38	6.76
NM41FVP[2]	12.26	3.19	1.17	2.33	0.341	7.3	1.36	6.80
NM42FVP[3]	12.39	3.16	1.18	2.31	0.336	7.33	1.42	6.68
NM43FVP[3]	12.64	3.22	1.19	2.35	0.335	7.33	1.4	6.63
NM45FVP[3]	12.56	3.24	1.19	2.31	0.353	7.34	1.34	6.60
NM48FVP[3]	12.33	3.28	1.17	2.33	0.339	7.39	1.34	6.87
Mean	12.39	3.20	1.15	2.34	0.344	7.29	1.37	6.69
Standard Deviation	0.14	0.03	0.03	0.04	0.009	0.08	0.02	0.10
Percent Standard Deviation (100·s/mean)	1.11	1.08	2.85	1.89	2.76	1.04	1.77	1.55

[1,2,3] Sample group

Appendix C

C:1 Isotopic and trace-element compositions of Lathrop Wells Basalts determined by solid-source mass spectrometry

Sample	LW11FVP	LW12FVP	LW20FVP	LW22FVP	LW113FVP	LW7FVP	LW41FVP	LW27FVP	LW29FVP	LW73FVP	LW96FVP	LW97FVP
Unit	Ql1a	Ql1a	Ql1d	Ql1d	Qs1u	Ql2a	Ql2a	Ql2b	Ql2b	Ql1b	Qs2fs	Qs2fs
Rb	19.70	19.10	17.76	15.68	20.60	19.90	20.47	19.36	19.60	17.80	20.50	20.40
Sr	1452	1446	1482	1495	1461	1399	1395	1424	1431	1485	1410	1413
$^{87}Sr/^{86}Sr$	0.707021	0.707047	0.707084	0.707077	0.707039	0.707006	0.707011	0.707033	0.707034	0.707084	0.706978	0.707044
Sm	12.43	12.33	12.56	12.79	12.40	12.00	12.05	12.16	12.26	12.50	12.10	12.00
Nd	90.10	89.11	90.50	91.99	89.20	86.50	87.30	87.99	88.44	89.83	87.60	86.70
$^{143}Nd/^{144}Nd$	0.512135	0.512110	0.512142	0.512142	0.512130	0.512123	0.512125	0.512114	0.512124	0.512128	0.512120	0.512123
ε_{Nd}	-9.81	-10.30	-9.68	-9.68	-9.91	-10.00	-10.01	-10.22	-10.03	-9.95	-10.10	-10.00
Pb	11.0	11.1	10.1	10.2	11.1	11.7	10.8	11.0	11.0	11.5	12.3	12.2
$^{208}Pb/^{204}Pb$	38.264	38.323	38.32	38.343	38.288	38.296	38.222	38.316	38.365	38.271	38.36	38.328
$^{207}Pb/^{204}Pb$	15.514	15.528	15.52	15.527	15.519	15.527	15.505	15.528	15.542	15.508	15.545	15.536
$^{206}Pb/^{204}Pb$	18.345	18.353	18.372	18.389	18.355	18.336	18.312	18.343	18.354	18.352	18.352	18.341

Appendix C

C:1 Isotopic and trace-element compositions of Lathrop Wells Basalts determined by solid-source mass spectrometry

Sample	LW118FVP	LW80FVP	LW81FVP	LW61FVP	LW15FVP	LW16FVP	LW78B	LW78R	LW133FVP
Unit	Qs2fs	Qs3	Qs3	Ql3	Qs4c	Qs4c	Qs4b	Qs4b	Qs4a
Rb	21.40	20.62	20.59	20.60	19.57	19.64	32.30	32.60	20.20
Sr	1386	1375	1361	1394	1321	1321	1277	1251	1350
$^{87}Sr/^{86}Sr$	0.707003	0.707024	0.707022	0.707085	0.707062	0.707062	0.707197	0.707266	0.707013
Sm	11.90	11.89	11.84	11.90	11.43	11.39	11.60	12.10	11.50
Nd	86.10	85.97	85.80	85.25	82.90	82.88	83.13	85.70	82.79
$^{143}Nd/^{144}Nd$	0.512113	0.512126	0.512138	0.512130	0.512120	0.512132	0.512121	0.512129	0.51122
ε_{Nd}	-10.20	-9.99	-9.75	-9.91	-10.10	-9.87	-10.1	-9.93	-10.1
Pb	11.8	14.9	13.1	12.5	12.4	11.2	16.9	42.3	12.3
$^{208}Pb/^{204}Pb$	38.323	38.032	38.288	38.255	38.269	38.33	38.277	38.251	38.226
$^{207}Pb/^{204}Pb$	15.535	15.486	15.54	15.515	15.52	15.537	15.503	15.508	15.508
$^{206}Pb/^{204}Pb$	18.361	18.17	18.522	18.339	18.332	18.349	18.381	18.375	18.328

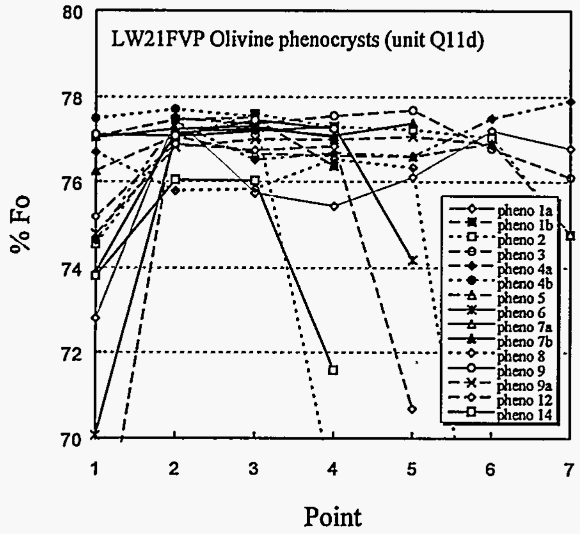
Appendix C

C:2 Replicate solid-source mass spectroscopy analyses of LW41FVP

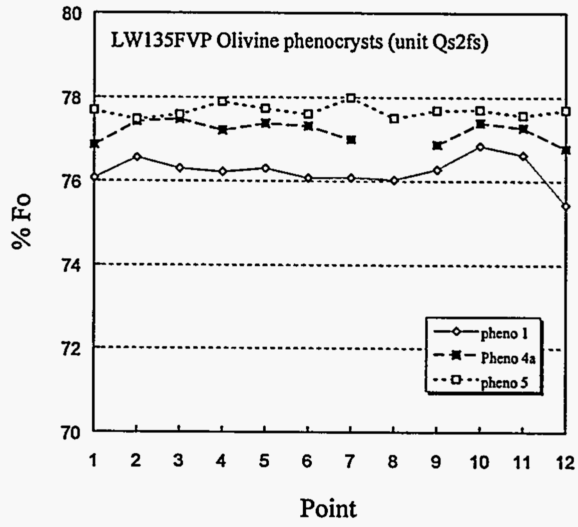
Sample	Rb	Sr	$^{87}Sr/^{86}Sr$	Sm	Nd	$^{143}Nd/^{144}Nd$	ε_{Nd}	Pb	$^{208}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{206}Pb/^{204}Pb$
LW41FVP	20.47	1395.00	0.707011	12.1	87.3	0.512125	-10.01	10.8	38.222	15.505	18.312
LW13FVP	19.54	1380.00	0.707042	12.0	87.1	0.512125	-10.01	10.8	38.231	15.51	18.322
DP3FVP	20.50	1407.00	0.707018	12.0	87.2	0.512118	-10.14	10.7	38.282	15.524	18.335
DP4FVP	20.50	1412.00	0.707002	11.9	87.2	0.512134	-9.83	10.8	38.329	15.538	18.343
DP5FVP	20.20	1398.00	0.707013	12.1	86.9	0.512127	-9.97	10.0	38.217	15.504	18.33
DP8FVP	20.20	1407.00	0.707007	12.0	86.6	0.512132	-9.87	10.5	38.24	15.511	18.328
Mean	20.24	1399.83	0.707016	12.01	87.04	0.512127	-9.97	10.59	38.254	15.515	18.328
Standard Deviation	0.37	11.58	0.000014	0.06	0.26	0.000006	0.11	0.34	0.044	0.013	0.011
Percent Standard Deviation (100·s/mean)	1.828	0.827	0.002	0.479	0.296	0.001	1.11	3.166	0.114	0.085	0.058

Appendix D

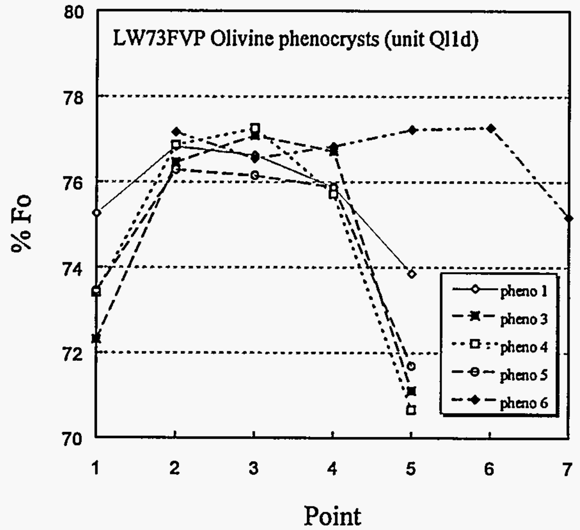
D:1



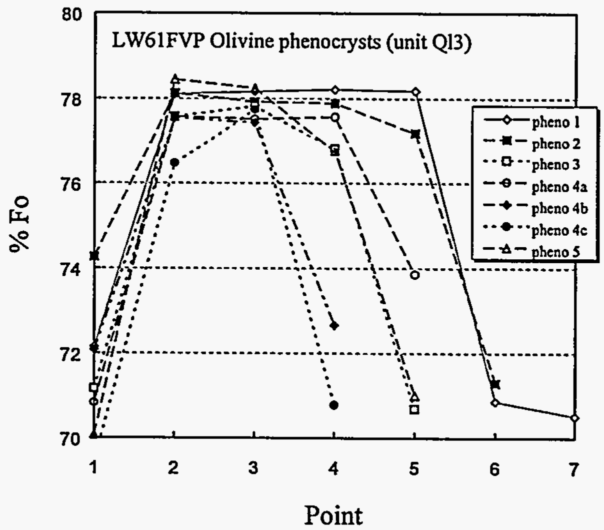
D:4



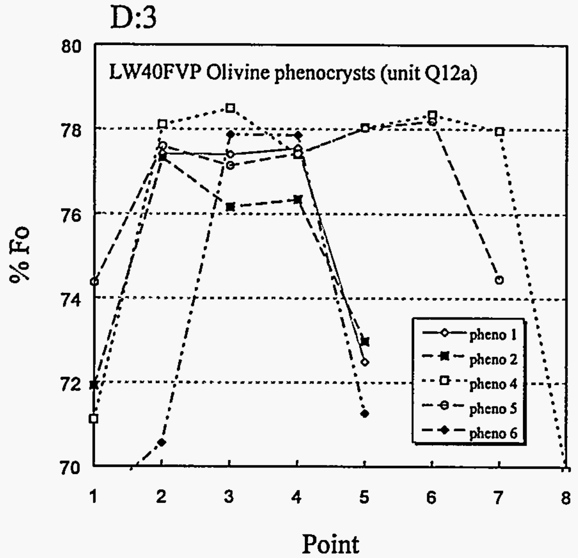
D:2



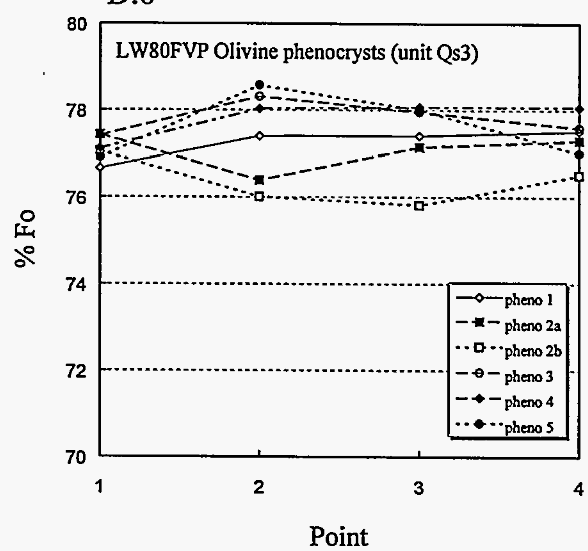
D:5



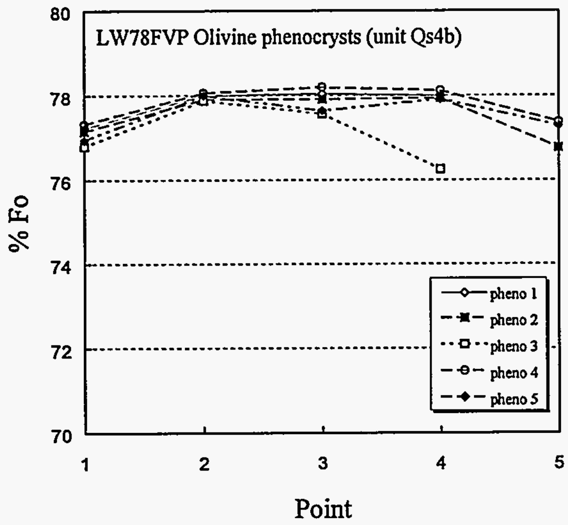
D:3



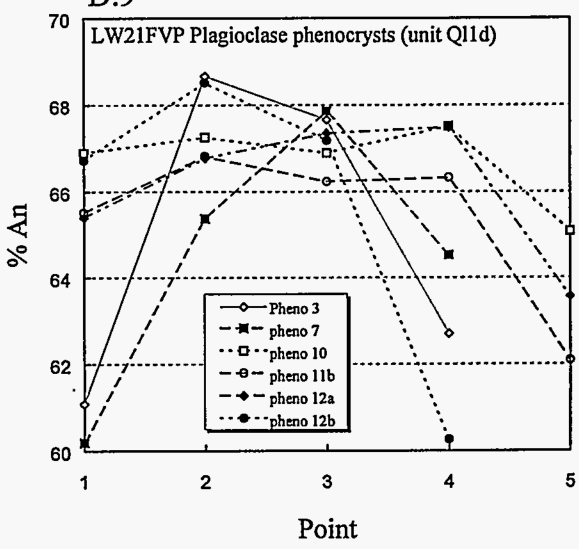
D:6



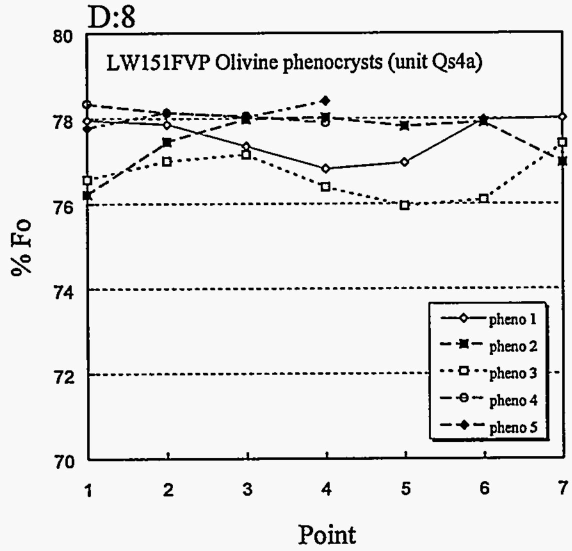
D:7


LW78FVP Olivine phenocrysts (unit Qs4b)
% Fo
Point
pheno 1
pheno 2
pheno 3
pheno 4
pheno 5
80
78
76
74
72
70
1
2
3
4
5

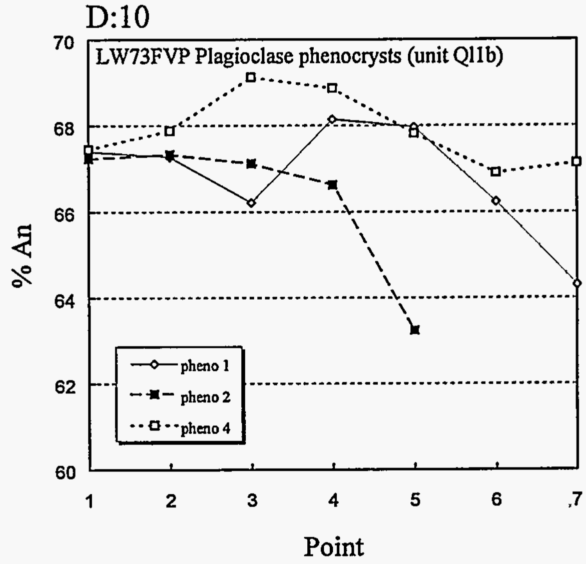
D:9


LW21FVP Plagioclase phenocrysts (unit Ql1d)
% An
Point
Pheno 3
pheno 7
pheno 10
pheno 11b
pheno 12a
pheno 12b
70
68
66
64
62
60
1
2
3
4
5

D:8

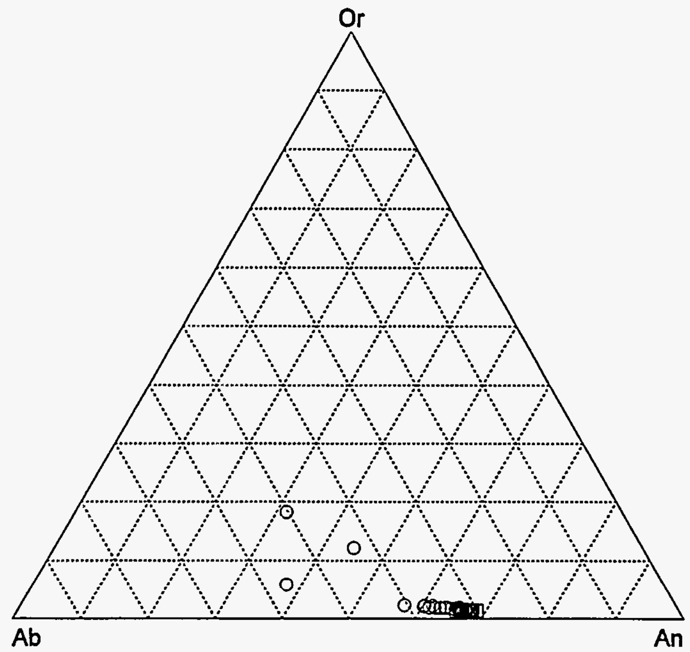

LW151FVP Olivine phenocrysts (unit Qs4a)
% Fo
Point
pheno 1
pheno 2
pheno 3
pheno 4
pheno 5
80
78
76
74
72
70
1
2
3
4
5
6
7

D:10


LW73FVP Plagioclase phenocrysts (unit Ql1b)
% An
Point
pheno 1
pheno 2
pheno 4
70
68
66
64
62
60
1
2
3
4
5
6
7

D:11

Feldspar compositions from LW21FVP of Ql1d plotted within the ternary field Or-Ab-An. Open squares are compositions of phenocryst interiors, open circles are compositions of phenocryst rims and groundmass crystals.



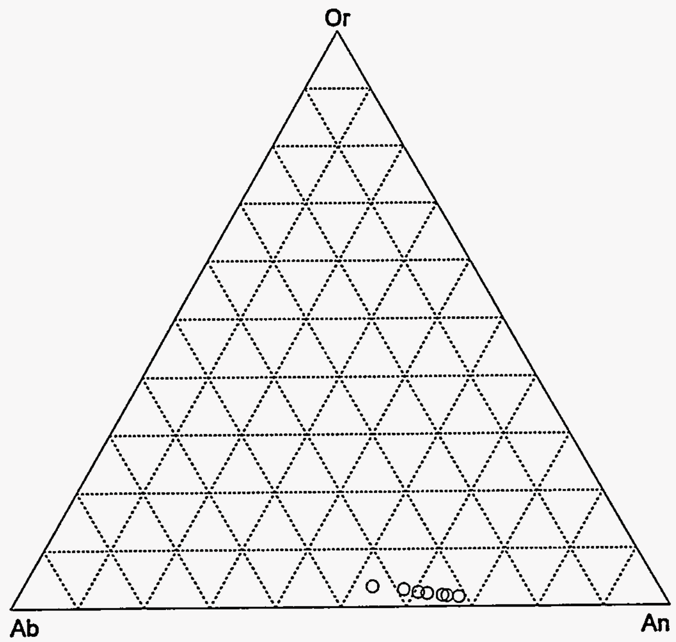
D:12

Feldspar compositions from LW73FVP of Ql1b plotted within the ternary field Or-Ab-An. Open squares are compositions of phenocryst interiors, open circles are compositions of phenocryst rims and groundmass crystals.

Appendix D

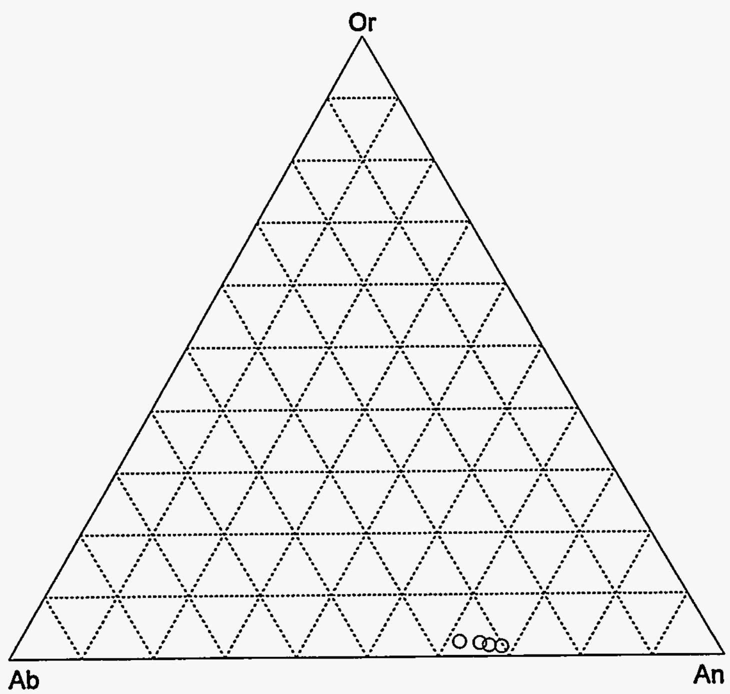
D:13

Feldspar compositions from LW40FVP of Ql2a plotted within the ternary field Or-Ab-An. Open circles are compositions of groundmass crystals.

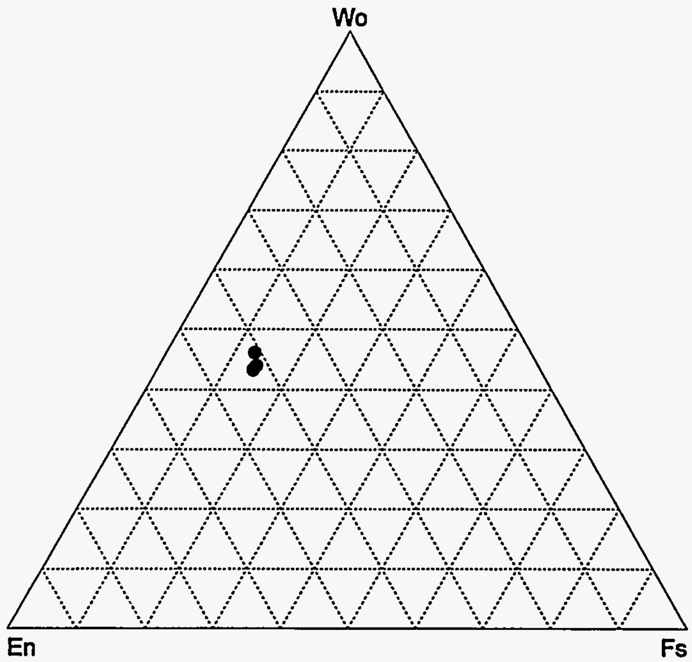


D:14

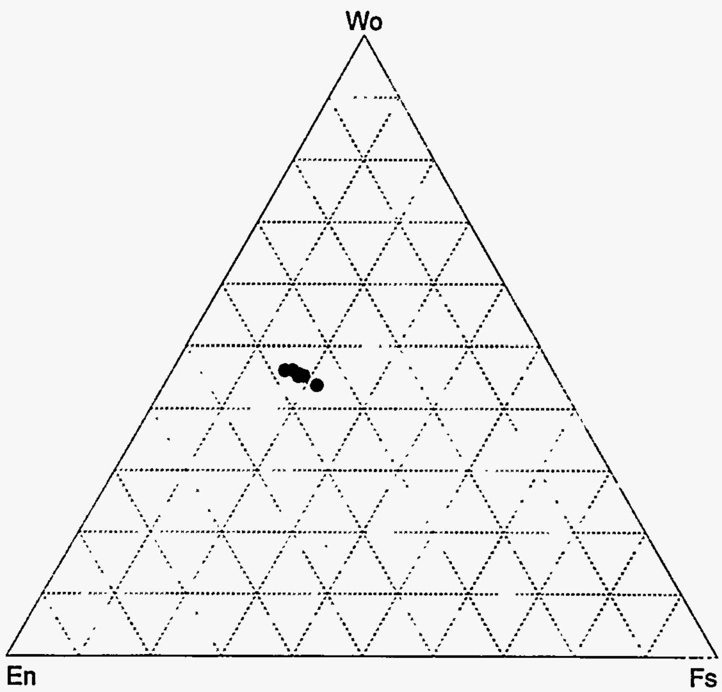
Feldspar compositions from LW61FVP of Ql3 plotted within the ternary field Or-Ab-An. Open circles are compositions of groundmass crystals.



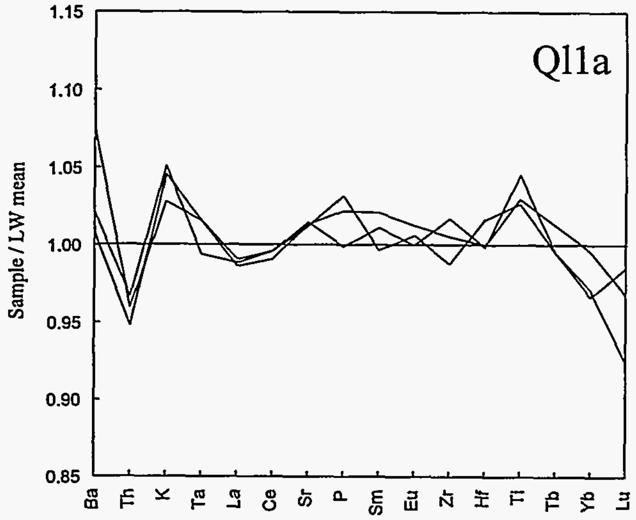
D:15
Pyroxene compositions from LW21FVP of Ql1d plotted within the ternary field Wo-En-Fs.
Filled circles are compositions of groundmass crystals.



D:16
Pyroxene compositions from LW40FVP of Ql2a plotted within the ternary field Wo-En-Fs.
Filled circles are compositions of groundmass crystals.

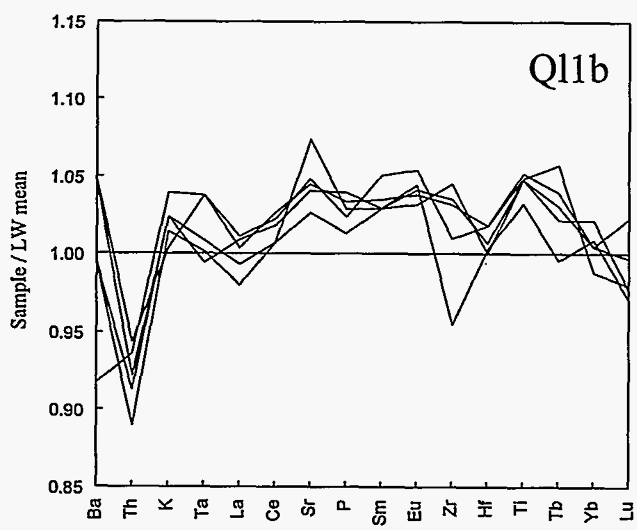


D:17



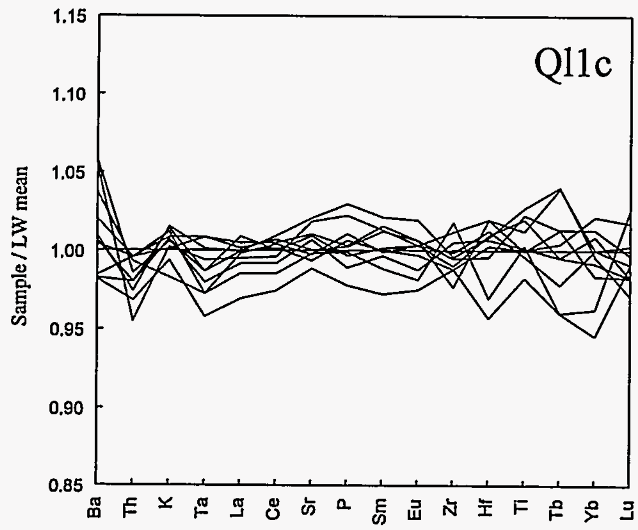
Line plot of incompatible element concentrations for samples of eruptive unit Ql1a normalized to the average concentration of each element for all analyzed Lathrop Wells samples (n=99). Normalizing values are Ba=1361.96 parts per million (ppm), Th=6.867 ppm, K=15,249.49 ppm, Ta=1.378 ppm, La=93.353 ppm, Ce=181.668 ppm, Sr=1469.56 ppm, P=5298.62 ppm, Sm=12.239 ppm, Eu=3.149 ppm, Zr=370.652 ppm, Hf=7.219 ppm, Ti=11,522.39 ppm, Tb=1.135 ppm, Yb=2.369 ppm, Lu=.344 ppm. Ba, K, Sr, P, Zr and Ti were determined by XRF; all other elements determined by INAA.

D:18



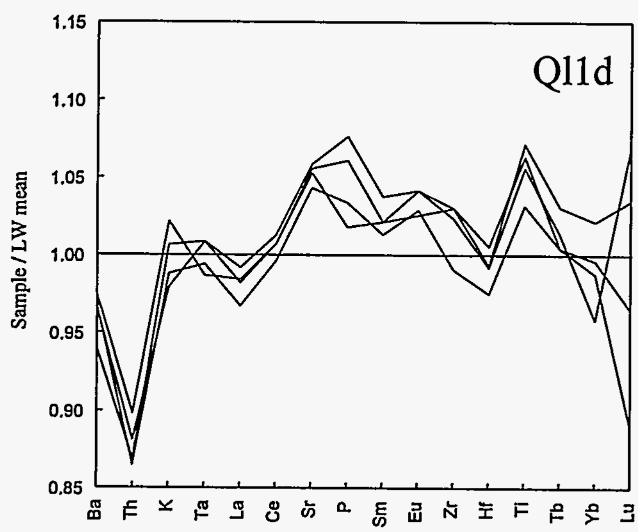
Line plot of incompatible element concentrations for samples of eruptive unit Ql1b normalized to the average concentration of each element for all analyzed Lathrop Wells samples (n=99).

D:19



Line plot of incompatible element concentrations for samples of eruptive unit Ql1c normalized to the average concentration of each element for all analyzed Lathrop Wells samples (n=99).

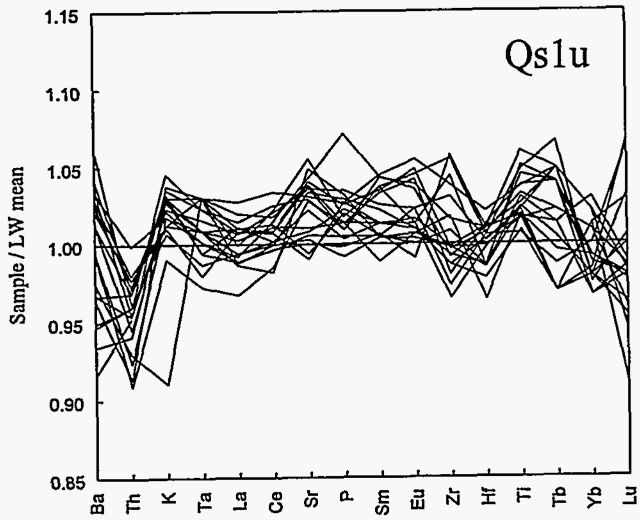
D:20



Line plot of incompatible element concentrations for samples of eruptive unit Ql1d normalized to the average concentration of each element for all analyzed Lathrop Wells samples (n=99).

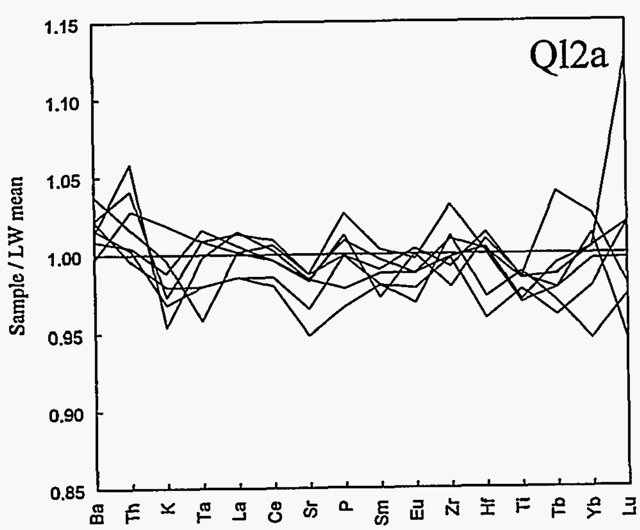
Appendix D

D:21



Line plot of incompatible element concentrations for samples of eruptive unit Qs1u normalized to the average concentration of each element for all analyzed Lathrop Wells samples (n=99). Qs1u represents all analyzed vents of chronostratigraphic unit I.

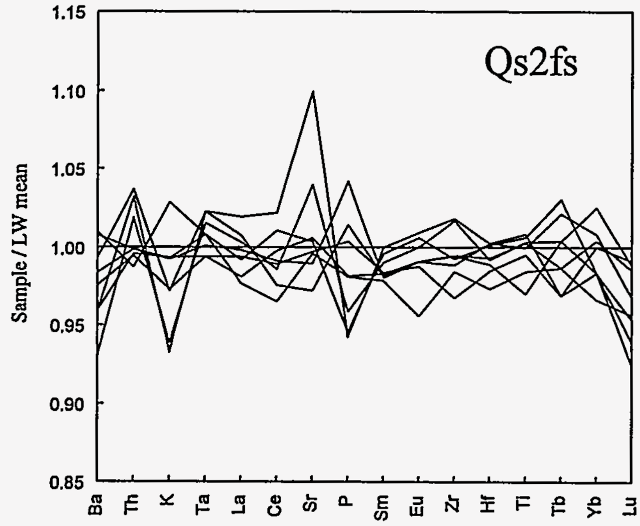
D:22



Line plot of incompatible element concentrations for samples of eruptive unit Ql2a normalized to the average concentration of each element for all analyzed Lathrop Wells samples (n=99).

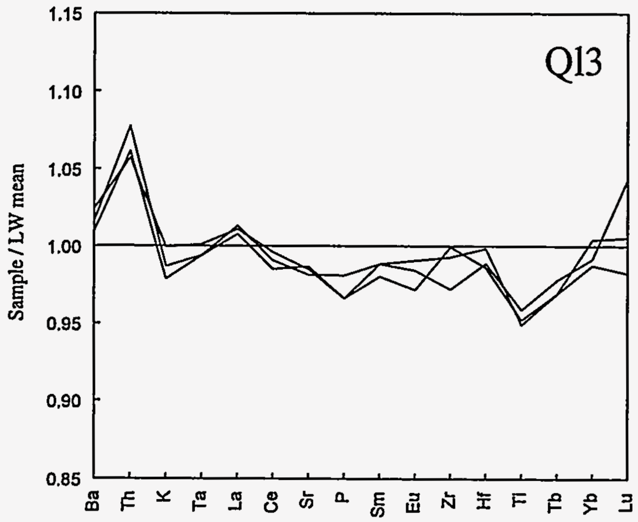
Appendix D

D:23



Line plot of incompatible element concentrations for samples of eruptive unit Qs2fs normalized to the average concentration of each element for all analyzed Lathrop Wells samples (n=99).

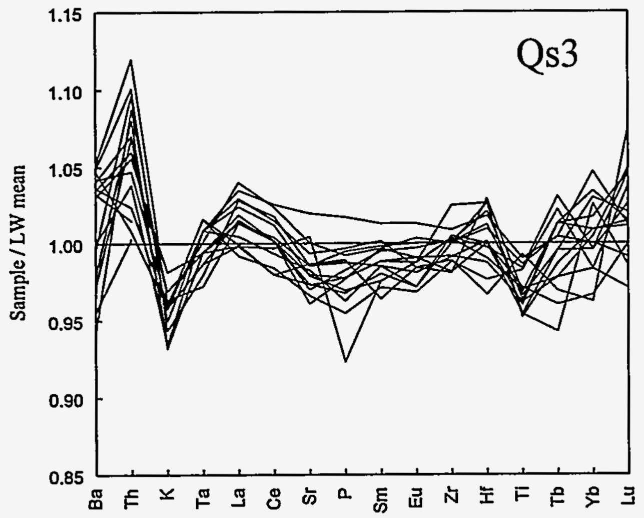
D:24



Line plot of incompatible element concentrations for samples of eruptive unit Ql3 normalized to the average concentration of each element for all analyzed Lathrop Wells samples (n=99).

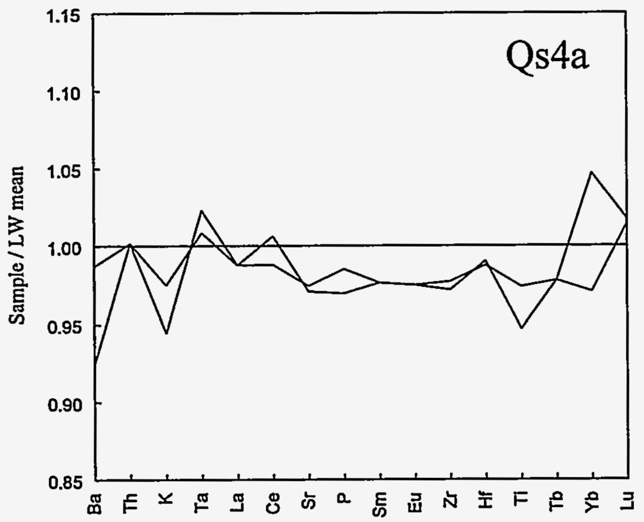
Appendix D

D:25



Line plot of incompatible element concentrations for samples of eruptive unit Qs3 normalized to the average concentration of each element for all analyzed Lathrop Wells samples (n=99).

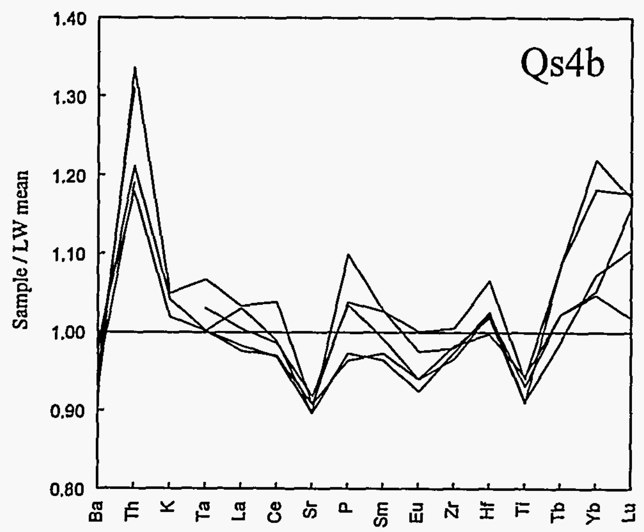
D:26



Line plot of incompatible element concentrations for samples of eruptive unit Qs4a normalized to the average concentration of each element for all analyzed Lathrop Wells samples (n=99).

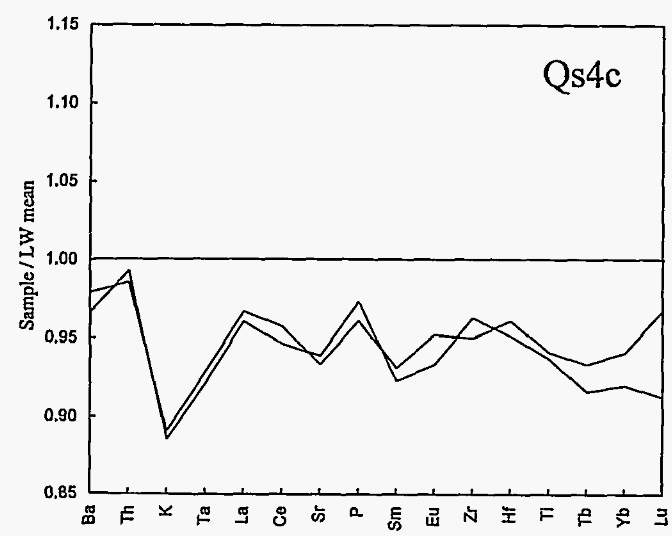
Appendix D

D:27



Line plot of incompatible element concentrations for samples of eruptive unit Qs4b normalized to the average concentration of each element for all analyzed Lathrop Wells samples (n=99).

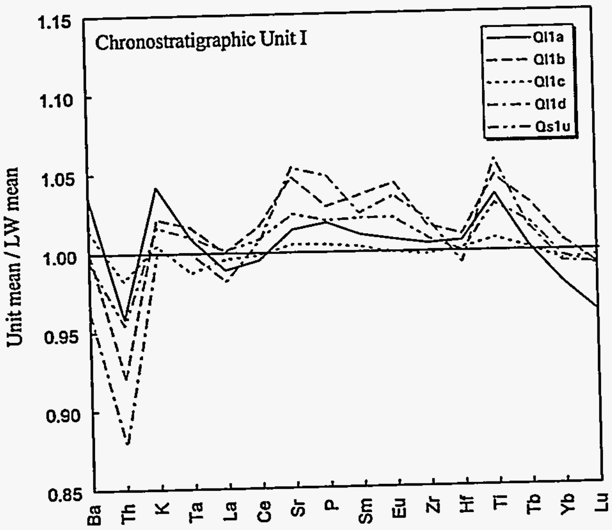
D:28



Line plot of incompatible element concentrations for samples of eruptive unit Qs4c normalized to the average concentration of each element for all analyzed Lathrop Wells samples (n=99).

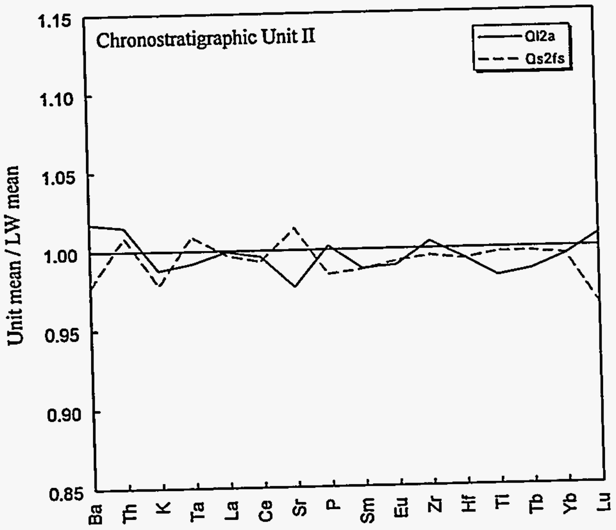
Appendix D

D:29



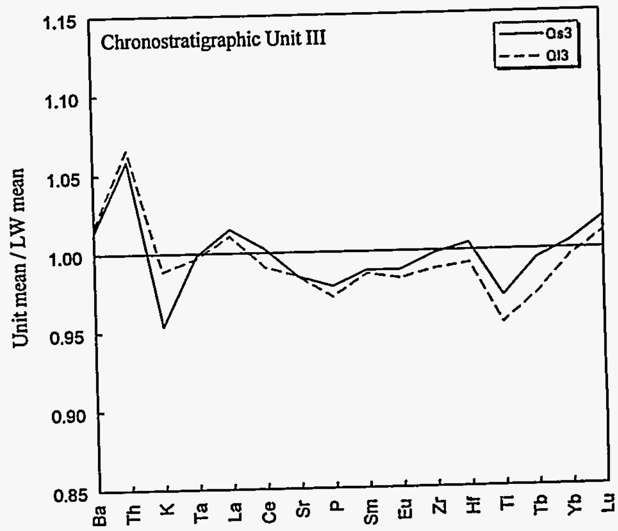
Line plot of average compositions of eruptive units from chronostratigraphic unit I.

D:30



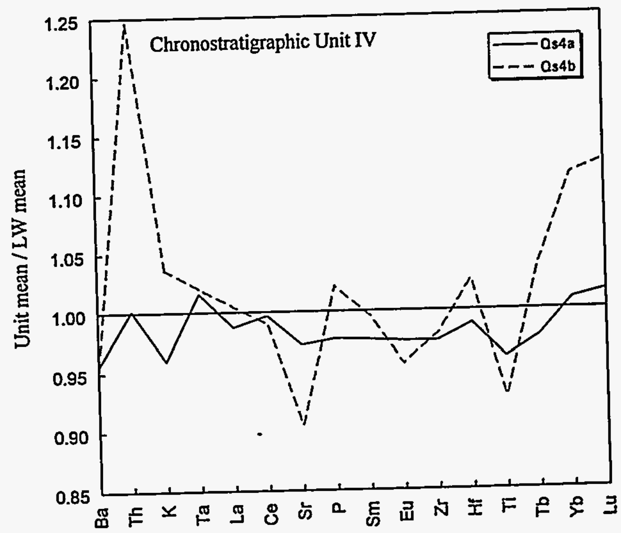
Line plot of average compositions of eruptive units from chronostratigraphic unit II.

D:31



Line plot of average compositions of eruptive units from chronostratigraphic unit III.

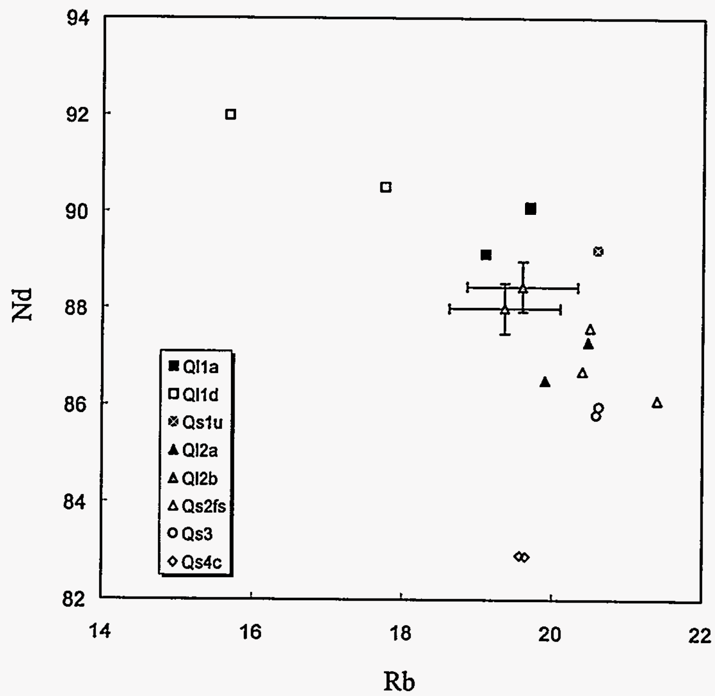
D:32



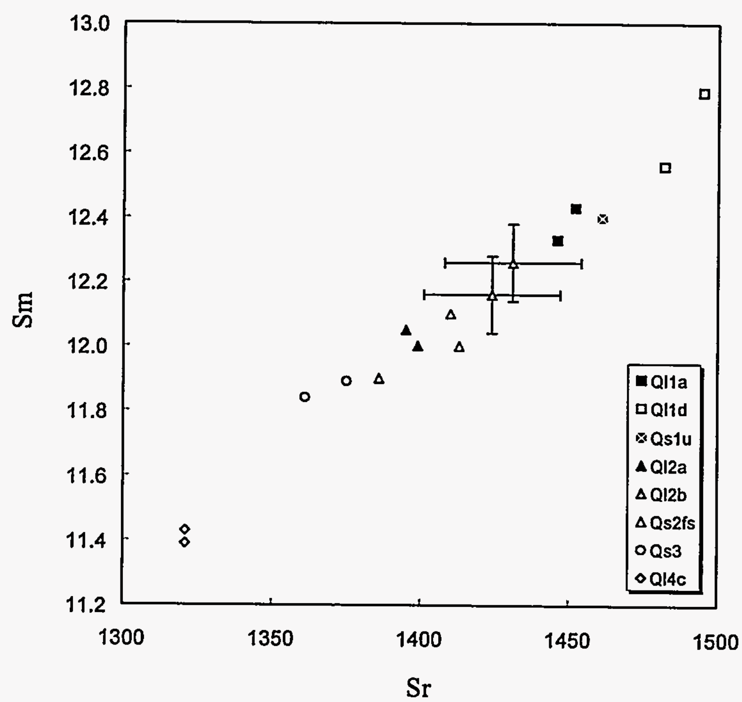
Line plot of average compositions of eruptive units from chronostratigraphic unit IV.

Appendix D

D:33
Rb versus Nd (ppm) for eruptive units of the Lathrop Wells volcanic center.

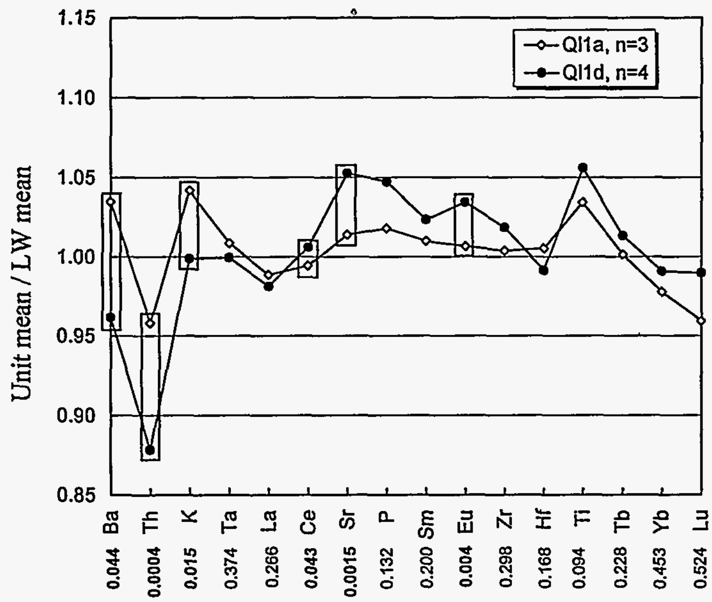


D:34
Sr versus Sm (ppm) for eruptive units of the Lathrop Wells volcanic center.



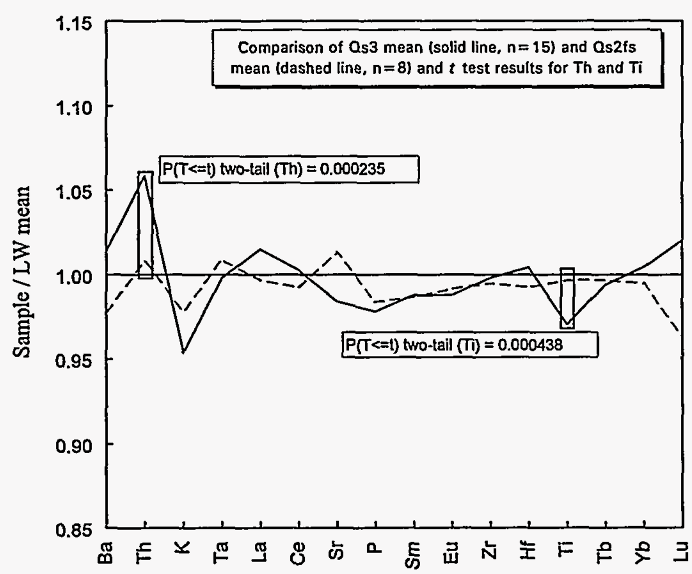
Appendix D

D:35



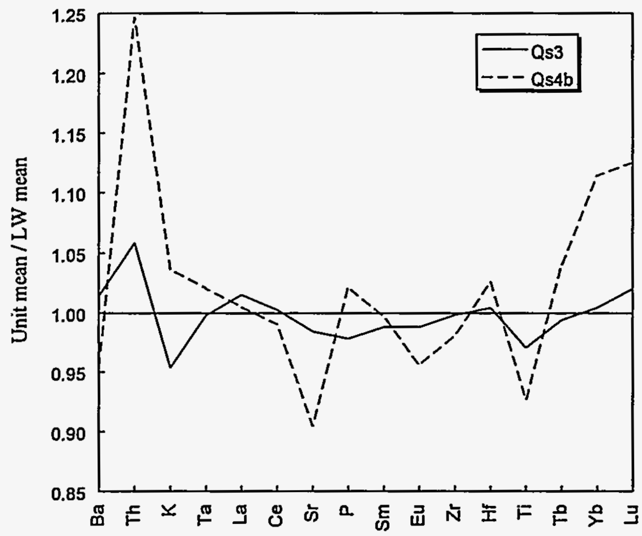
Line plot comparing average compositions of eruptive units Ql1a and Ql1d. Values below each element are the probability that the sample means of each element represent the same populations using the two-tailed *t* test. Values in bold indicate elements with statistically significant (95% confidence level) differences in average composition (also indicated by data points enclosed in rectangles).

D:36



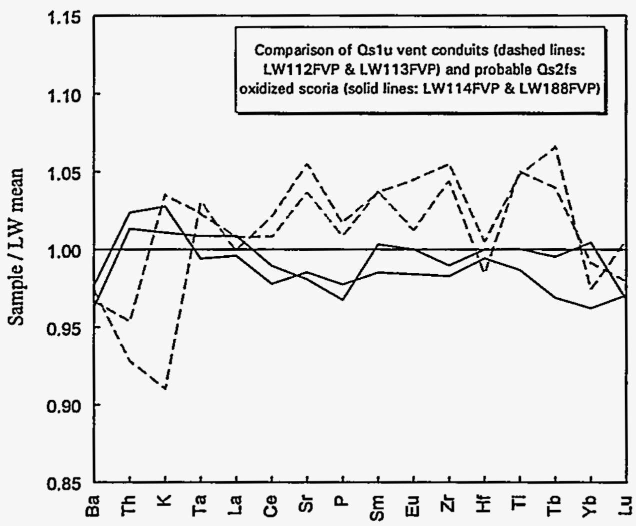
Line plot comparing average compositions of eruptive units Qs3 and Qs2fs. Average concentrations of Th and Ti for the two units are statistically different at the 95% confidence level using the two-tailed *t* test.

D:37



Line plot comparing average compositions of eruptive units Qs3 and Qs4b.

D:38



Line plot comparing samples from Qs1 vent conduits (dashed lines) and samples of oxidized scoria that are probably part of scoria fall sheet Qs2fs (solid lines).

Appendix E

E:1 Composition of olivine phenocrysts and groundmass (gm) from LW21FVP of Ql1d

Point	lw21fvp_#1ab	lw21fvp_#1a	lw21fvp_#1a	lw21fvp_#1a	lw21fvp_#1a	lw21fvp_#1a	lw21fvp_#1ae	lw21fvp_#1bb	lw21fvp_#1b
SiO_2	38.04	38.80	38.26	37.99	38.26	38.09	37.96	38.16	38.00
MgO	36.91	40.19	38.85	38.75	39.21	40.09	39.73	39.74	39.98
FeO	24.46	20.70	22.04	22.35	21.78	20.96	21.32	21.00	20.59
CaO	0.19	0.14	0.15	0.13	0.13	0.13	0.17	0.16	0.14
MnO	0.35	0.30	0.32	0.29	0.31	0.28	0.30	0.26	0.32
NiO	0.13	0.29	0.16	0.18	0.21	0.25	0.23	0.24	0.27
TOTAL	100.08	100.42	99.76	99.69	99.90	99.79	99.70	99.56	99.29
Cations[1]									
Si	1.00	1.00	1.00	0.99	1.00	0.99	0.99	0.99	0.99
Mg	1.45	1.54	1.51	1.51	1.52	1.55	1.54	1.54	1.55
Fe	0.54	0.45	0.48	0.49	0.47	0.46	0.46	0.46	0.45
Ca	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Fo	72.81	77.48	75.75	75.45	76.11	77.22	76.80	77.08	77.46
Fa	27.06	22.39	24.11	24.41	23.73	22.65	23.12	22.85	22.38

[1]based on 4 oxygens

Appendix E

E:1 Composition of olivine phenocrysts and groundmass (gm) from LW21FVP of Ql1d

Point	lw21fvp_#1b	lw21fvp_#1be	lw21fvp_#2b	lw21fvp_#2	lw21fvp_#2	lw21fvp_#2	lw21fvp_#2	lw21fvp_#2	lw21fvp_#2e	lw21fvp_3b
SiO_2	38.10	37.62	37.64	37.73	38.08	38.62	38.26	38.17	37.63	35.92
MgO	40.12	39.17	38.18	40.02	40.24	40.43	40.10	39.97	38.27	32.51
FeO	20.65	21.57	23.24	21.16	20.59	20.99	20.94	21.08	22.90	29.51
CaO	0.14	0.19	0.25	0.13	0.12	0.14	0.14	0.14	0.19	0.29
MnO	0.27	0.28	0.30	0.25	0.27	0.33	0.29	0.32	0.34	0.55
NiO	0.23	0.16	0.05	0.23	0.23	0.24	0.26	0.22	0.16	0.04
TOTAL	99.50	98.98	99.68	99.51	99.53	100.75	100.01	99.90	99.48	98.82
Cations[1]										
Si	0.99	0.99	0.99	0.98	0.99	0.99	0.99	0.99	0.99	0.99
Mg	1.56	1.53	1.50	1.56	1.56	1.55	1.55	1.55	1.50	1.33
Fe	0.45	0.47	0.51	0.46	0.45	0.45	0.45	0.46	0.50	0.68
Ca	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Fo	77.51	76.37	74.55	77.05	77.60	77.30	77.24	77.05	74.78	66.11
Fa	22.39	23.59	25.46	22.86	22.27	22.52	22.63	22.80	25.10	33.68

[1]based on 4 oxygens

Appendix E

E:1 Composition of olivine phenocrysts and groundmass (gm) from LW21FVP of Ql1d

Point	lw21fvp_3	lw21fvp_3	lw21fvp_3	lw21fvp_3	lw21fvp_3	lw21fvp_3e	lw21fvp_#4ab	lw21fvp_#4a	lw21fvp_#4a	lw21fvp_#4a
SiO_2	37.81	37.41	37.46	37.19	37.03	36.80	37.32	37.60	37.81	37.73
MgO	40.34	40.35	40.15	39.97	39.64	38.96	38.07	40.06	39.47	39.40
FeO	20.82	20.92	20.61	20.39	21.28	21.71	23.02	20.73	21.53	21.26
CaO	0.14	0.12	0.13	0.14	0.17	0.17	0.26	0.15	0.16	0.15
MnO	0.23	0.26	0.26	0.26	0.30	0.31	0.36	0.28	0.26	0.28
NiO	0.31	0.29	0.26	0.28	0.22	0.11	0.12	0.21	0.19	0.18
TOTAL	99.64	99.36	98.86	98.23	98.63	98.06	99.15	99.04	99.42	98.99
Cations[1]										
Si	0.98	0.98	0.98	0.98	0.98	0.98	0.99	0.98	0.99	0.99
Mg	1.56	1.57	1.57	1.57	1.56	1.55	1.50	1.56	1.54	1.54
Fe	0.45	0.46	0.45	0.45	0.47	0.48	0.51	0.45	0.47	0.47
Ca	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Fo	77.50	77.37	77.55	77.68	76.78	76.10	74.64	77.43	76.52	76.68
Fa	22.44	22.51	22.34	22.23	23.13	23.79	25.33	22.47	23.42	23.22

[1]based on 4 oxygens

Appendix E

E:1 Composition of olivine phenocrysts and groundmass (gm) from LW21FVP of Ql1d

Point	lw21fvp_#4a	lw21fvp_#4a	lw21fvp_#4ae	lw21fvp_#4bb	lw21fvp_#4b	lw21fvp_#4b	lw21fvp_#4be	lw21fvp_#5ab	lw21fvp_#5a
SiO_2	37.66	37.89	37.81	38.19	38.08	38.23	36.36	37.88	38.19
MgO	39.58	40.05	40.12	40.29	40.38	40.21	34.10	39.35	39.72
FeO	21.39	20.62	20.14	20.72	20.57	20.68	27.65	21.79	20.96
CaO	0.14	0.12	0.15	0.12	0.15	0.14	0.48	0.21	0.17
MnO	0.33	0.26	0.33	0.28	0.27	0.25	0.44	0.32	0.29
NiO	0.22	0.22	0.16	0.20	0.27	0.23	0.15	0.07	0.18
TOTAL	99.32	99.16	98.70	99.80	99.72	99.75	99.17	99.61	99.50
Cations[1]									
Si	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Mg	1.54	1.56	1.57	1.56	1.56	1.55	1.38	1.53	1.54
Fe	0.47	0.45	0.44	0.45	0.45	0.45	0.63	0.48	0.46
Ca	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00
Fo	76.61	77.50	77.91	77.50	77.71	77.54	68.86	76.25	77.09
Fa	23.22	22.39	21.94	22.36	22.21	22.37	31.33	23.69	22.82

[1]based on 4 oxygens

Appendix E

E:1 Composition of olivine phenocrysts and groundmass (gm) from LW21FVP of Ql1d

Point	lw21fvp_#5a	lw21fvp_#5a	lw21fvp_#5a	lw21fvp_#5a	lw21fvp_#5ae	lw21fvp_#6b	lw21fvp_#6	lw21fvp_#6	lw21fvp_#6	lw21fvp_#6e
SiO_2	38.35	38.27	38.28	38.24	38.00	36.97	38.20	37.54	38.15	37.83
MgO	39.98	39.68	39.82	39.97	38.41	34.98	39.85	39.96	40.27	37.93
FeO	21.60	21.52	21.58	21.22	22.94	26.54	21.06	20.89	20.97	23.43
CaO	0.13	0.13	0.13	0.12	0.17	0.25	0.14	0.12	0.15	0.20
MnO	0.25	0.23	0.26	0.30	0.34	0.40	0.23	0.29	0.27	0.34
NiO	0.29	0.16	0.26	0.24	0.11	0.12	0.27	0.22	0.23	0.19
TOTAL	100.60	100.00	100.33	100.08	99.95	99.25	99.75	99.00	100.04	99.91
Cations[1]										
Si	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.98	0.99	0.99
Mg	1.54	1.54	1.54	1.54	1.50	1.40	1.54	1.56	1.56	1.48
Fe	0.47	0.47	0.47	0.46	0.50	0.60	0.46	0.46	0.45	0.51
Ca	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00
Fo	76.67	76.61	76.60	76.92	74.80	70.07	77.09	77.20	77.32	74.19
Fa	23.24	23.31	23.29	22.92	25.06	29.84	22.86	22.64	22.59	25.72

[1]based on 4 oxygens

Appendix E

E:1 Composition of olivine phenocrysts and groundmass (gm) from LW21FVP of Ql1d

Point	lw21fvp_7a	lw21fvp_7a	lw21fvp_7a	lw21fvp_7a	lw21fvp_7a	lw21fvp_7b	lw21fvp_7b	lw21fvp_7b	lw21fvp_7b	lw21fvp_8b
SiO_2	37.61	38.16	38.10	38.24	38.25	38.33	38.26	38.20	38.30	37.56
MgO	37.39	40.26	40.36	40.14	40.24	40.20	40.24	40.07	39.98	39.80
FeO	23.52	21.20	21.13	21.12	20.89	21.25	21.01	20.93	21.17	21.47
CaO	0.25	0.16	0.16	0.12	0.13	0.18	0.13	0.15	0.16	0.15
MnO	0.33	0.23	0.24	0.26	0.23	0.30	0.27	0.21	0.24	0.25
NiO	0.14	0.21	0.20	0.23	0.23	0.21	0.28	0.23	0.24	0.26
TOTAL	99.25	100.22	100.18	100.11	99.98	100.46	100.19	99.79	100.07	99.49
Cations[1]										
Si	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.98
Mg	1.47	1.55	1.56	1.55	1.55	1.55	1.55	1.55	1.54	1.55
Fe	0.52	0.46	0.46	0.46	0.45	0.46	0.45	0.45	0.46	0.47
Ca	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01
Fo	73.91	77.18	77.26	77.11	77.39	77.06	77.26	77.32	77.06	76.71
Fa	26.08	22.80	22.70	22.77	22.54	22.85	22.63	22.66	22.90	23.22

[1]based on 4 oxygens

Appendix E

E:1 Composition of olivine phenocrysts and groundmass (gm) from LW21FVP of Ql1d

Point	lw21fvp_8	lw21fvp_8	lw21fvp_8	lw21fvp_8	lw21fvp_8e	lw21fvp_9b	lw21fvp_9	lw21fvp_9	lw21fvp_9e	lw21fvp_9ab	lw21fvp_9a
SiO_2	37.47	37.37	37.52	37.61	35.61	37.68	37.44	37.62	37.57	37.25	37.78
MgO	39.09	39.25	39.57	39.40	31.69	39.86	40.00	40.10	40.10	38.15	39.69
FeO	22.14	22.12	21.52	21.66	30.64	21.00	21.08	20.71	20.93	22.86	21.31
CaO	0.16	0.10	0.15	0.17	0.35	0.16	0.13	0.12	0.15	0.25	0.15
MnO	0.30	0.29	0.29	0.32	0.58	0.28	0.27	0.25	0.29	0.37	0.22
NiO	0.21	0.14	0.28	0.21	0.03	0.30	0.25	0.27	0.25	0.10	0.21
TOTAL	99.37	99.27	99.33	99.38	98.90	99.28	99.17	99.06	99.29	98.97	99.36
Cations[1]											
Si	0.98	0.98	0.98	0.99	0.98	0.99	0.98	0.98	0.98	0.99	0.99
Mg	1.53	1.54	1.55	1.54	1.30	1.55	1.56	1.56	1.56	1.51	1.55
Fe	0.49	0.49	0.47	0.48	0.71	0.46	0.46	0.45	0.46	0.51	0.47
Ca	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00
Fo	75.80	75.84	76.53	76.33	64.72	77.13	77.10	77.46	77.26	74.80	76.83
Fa	24.09	23.98	23.35	23.55	35.12	22.79	22.79	22.44	22.62	25.15	23.14

[1]based on 4 oxygens

Appendix E

E:1 Composition of olivine phenocrysts and groundmass (gm) from LW21FVP of Ql1d

Point	lw21fvp_9a	lw21fvp_9a	lw21fvp_9a	lw21fvp_9ae	lw21fvp_#12b	lw21fvp_#12	lw21fvp_#12	lw21fvp_#12	lw21fvp_#12e
SiO_2	37.64	37.53	37.43	37.55	37.87	38.45	38.26	38.24	37.43
MgO	39.70	40.13	39.94	39.89	38.41	39.92	39.92	39.81	35.52
FeO	21.05	21.26	21.09	21.34	22.77	21.31	21.46	21.28	26.02
CaO	0.15	0.15	0.15	0.20	0.42	0.17	0.16	0.15	0.24
MnO	0.26	0.29	0.26	0.27	0.33	0.27	0.29	0.28	0.53
NiO	0.21	0.18	0.20	0.21	0.07	0.16	0.20	0.16	0.14
TOTAL	99.01	99.54	99.07	99.45	99.85	100.27	100.29	99.92	99.88
Cations[1]									
Si	0.99	0.98	0.98	0.98	0.99	0.99	0.99	0.99	1.00
Mg	1.55	1.56	1.56	1.55	1.50	1.54	1.54	1.54	1.41
Fe	0.46	0.46	0.46	0.47	0.50	0.46	0.47	0.46	0.58
Ca	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fo	77.01	77.01	77.08	76.90	75.20	76.90	76.75	76.84	70.69
Fa	22.91	22.89	22.84	23.08	25.02	23.04	23.15	23.05	29.05

[1]based on 4 oxygens

Appendix E

E:1 Composition of olivine phenocrysts and groundmass (gm) from LW21FVP of Ql1d

Point	lw21fvp_#14b	lw21fvp_#14	lw21fvp_#14	lw21fvp_#14e	lw21fvp_#13a gm	lw21fvp_#13a gm	lw21fvp_#13bb gm	lw21fvp_#13b gm
SiO_2	37.87	38.79	38.41	37.45	35.73	36.55	35.86	35.92
MgO	37.91	38.49	39.18	35.94	30.99	32.14	29.15	31.42
FeO	23.90	21.58	21.98	25.31	30.09	29.41	32.89	30.32
CaO	0.19	0.22	0.22	0.26	1.17	0.36	0.34	0.73
MnO	0.32	0.31	0.31	0.43	0.60	0.62	0.66	0.58
NiO	0.11	0.12	0.12	0.10	0.02	0.02	0.01	0.08
TOTAL	100.30	99.51	100.22	99.49	98.59	99.11	98.92	99.06
Cations[1]								
Si	0.99	1.01	1.00	1.00	0.99	1.00	1.00	0.99
Mg	1.48	1.49	1.52	1.43	1.28	1.31	1.21	1.29
Fe	0.52	0.47	0.48	0.56	0.70	0.67	0.77	0.70
Ca	0.01	0.01	0.01	0.01	0.04	0.01	0.01	0.02
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01
Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fo	73.81	76.05	76.03	71.59	65.42	65.95	61.07	65.14
Fa	26.11	23.92	23.93	28.29	35.64	33.86	38.66	35.26

[1]based on 4 oxygens

Appendix E

E:1 Composition of olivine phenocrysts and groundmass (gm) from LW21FVP of Ql1d

Point	lw21fvp_#13be gm	lw21fvp_#14ab gm	lw21fvp_#14ae gm	lw21fvp_#14a gm	lw21fvp_#14bb gm	lw21fvp_#14b gm
SiO_2	35.23	36.73	36.80	37.47	35.34	35.54
MgO	28.25	35.15	35.80	35.43	27.81	28.17
FeO	32.97	25.77	25.04	25.97	33.93	33.87
CaO	1.29	0.70	0.92	0.38	0.45	0.63
MnO	0.61	0.45	0.43	0.43	0.74	0.80
NiO	0.00	0.05	0.07	0.04	0.04	0.03
TOTAL	98.34	98.85	99.06	99.70	98.32	99.04
Cations[1]						
Si	0.99	0.99	0.99	1.00	1.00	1.00
Mg	1.19	1.41	1.43	1.41	1.17	1.18
Fe	0.78	0.58	0.56	0.58	0.80	0.79
Ca	0.04	0.02	0.03	0.01	0.01	0.02
Mn	0.02	0.01	0.01	0.01	0.02	0.02
Ni	0.00	0.00	0.00	0.00	0.00	0.00
Fo	61.19	71.21	72.42	70.91	59.24	59.71
Fa	40.06	29.29	28.42	29.16	40.56	40.28

[1]based on 4 oxygens

Appendix E

E:2 Composition of olivine phenocrysts from LW73FVP of Ql1b

Point	lw73fvp_#1b	lw73fvp_#1	lw73fvp_#1	lw73fvp_#1	lw73fvp_#1e	lw73fvp_#3b	lw73fvp_#3	lw73fvp_#3	lw73fvp_#3	lw73fvp_#3e
SiO_2	37.52	37.20	37.80	37.73	37.04	35.92	36.56	36.89	37.99	35.50
MgO	38.69	39.81	39.69	39.19	37.56	36.80	39.66	40.20	40.22	34.99
FeO	22.49	21.32	21.57	22.14	23.56	24.95	21.72	21.16	21.60	25.99
CaO	0.16	0.18	0.17	0.18	0.18	0.20	0.15	0.15	0.16	0.84
MnO	0.37	0.31	0.23	0.30	0.37	0.41	0.24	0.30	0.36	0.43
NiO	0.16	0.13	0.18	0.17	0.16	0.04	0.19	0.24	0.21	0.13
TOTAL	99.39	98.94	99.65	99.72	98.87	98.31	98.52	98.94	100.53	97.88
Cations[1]										
Si	0.99	0.98	0.99	0.99	0.99	0.97	0.97	0.97	0.98	0.97
Mg	1.52	1.56	1.54	1.53	1.49	1.48	1.57	1.58	1.55	1.43
Fe	0.50	0.47	0.47	0.48	0.52	0.56	0.48	0.47	0.47	0.59
Ca	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.03
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Fo	75.26	76.82	76.62	75.87	73.86	72.31	76.45	77.10	76.71	71.10
Fa	24.55	23.08	23.36	24.05	25.99	27.51	23.49	22.78	23.11	29.64

[1]based on 4 oxygens

Appendix E

E:2 Composition of olivine phenocrysts from LW73FVP of Ql1b

Point	lw73fvp_#4b	lw73fvp_#4	lw73fvp_#4	lw73fvp_#4	lw73fvp_#4e	lw73fvp_#5b	lw73fvp_#5	lw73fvp_#5	lw73fvp_#5	lw73fvp_#5e
SiO_2	37.60	38.14	37.34	37.20	36.10	37.05	37.12	37.12	37.86	37.17
MgO	37.61	39.74	40.50	39.31	35.60	37.44	39.75	39.46	39.44	36.61
FeO	24.14	21.21	21.17	22.31	26.30	24.03	21.92	21.91	22.19	25.60
CaO	0.21	0.13	0.13	0.15	0.28	0.20	0.15	0.15	0.15	0.19
MnO	0.41	0.27	0.23	0.34	0.41	0.32	0.30	0.31	0.34	0.40
NiO	0.22	0.23	0.19	0.23	0.08	0.22	0.30	0.19	0.16	0.06
TOTAL	100.19	99.73	99.56	99.55	98.77	99.26	99.54	99.14	100.15	100.03
Cations[1]										
Si	0.99	0.99	0.98	0.98	0.98	0.98	0.97	0.98	0.99	0.99
Mg	1.47	1.54	1.58	1.54	1.43	1.48	1.55	1.55	1.53	1.45
Fe	0.53	0.46	0.46	0.49	0.59	0.53	0.48	0.48	0.48	0.57
Ca	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.01	0.01	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00
Fo	73.40	76.87	77.27	75.72	70.66	73.46	76.28	76.14	75.88	71.69
Fa	26.44	23.01	22.66	24.12	29.28	26.46	23.60	23.73	23.96	28.13

[1]based on 4 oxygens

Appendix E

E:2 Composition of olivine phenocrysts from LW73FVP of Ql1b

Point	lw73fvp_#6	lw73fvp_#6	lw73fvp_#6	lw73fvp_#6	lw73fvp_#6
SiO_2	37.79	38.51	38.14	38.20	37.94
MgO	40.31	39.82	40.15	40.65	40.43
FeO	21.25	21.76	21.58	21.35	21.20
CaO	0.19	0.19	0.20	0.20	0.19
MnO	0.23	0.24	0.26	0.24	0.22
NiO	0.10	0.03	0.05	0.05	0.02
TOTAL	99.87	100.55	100.37	100.69	99.99
Cations[1]					
Si	0.98	0.99	0.99	0.98	0.98
Mg	1.56	1.53	1.55	1.56	1.56
Fe	0.46	0.47	0.47	0.46	0.46
Ca	0.01	0.01	0.01	0.01	0.01
Mn	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.00	0.00	0.00	0.00
Fo	77.18	76.53	76.83	77.24	77.29
Fa	22.83	23.46	23.17	22.77	22.74

[1]based on 4 oxygens

Appendix E

E:3 Composition of olivine phenocrysts from LW40FVP of Ql2a

Point	lw40fvp#1a	lw40fvp#1b	lw40fvp#1c	lw40fvp#1d	lw40fvp#2b	lw40fvp#2	lw40fvp#2	lw40fvp#2	lw40fvp#2e	lw40fvp#4a	lw40fvp#4b
SiO_2	38.11	38.12	37.95	37.01	37.11	37.99	37.94	37.83	37.32	36.88	37.99
MgO	40.32	40.56	40.38	36.92	36.45	40.53	39.17	39.98	37.23	36.29	40.76
FeO	20.89	21.04	20.75	24.91	25.32	21.08	21.69	21.93	24.53	26.17	20.29
CaO	0.12	0.12	0.14	0.23	0.27	0.11	0.11	0.09	0.22	0.26	0.14
MnO	0.23	0.21	0.27	0.36	0.38	0.24	0.30	0.26	0.32	0.43	0.26
NiO	0.30	0.32	0.13	0.16	0.10	0.23	0.33	0.20	0.10	0.04	0.20
TOTAL	99.97	100.36	99.61	99.59	99.62	100.18	99.54	100.29	99.72	100.07	99.63
Cations[1]											
Si	0.99	0.99	0.99	0.98	0.99	0.98	0.99	0.98	0.99	0.98	0.99
Mg	1.56	1.56	1.56	1.46	1.45	1.56	1.53	1.55	1.47	1.44	1.58
Fe	0.45	0.46	0.45	0.55	0.56	0.46	0.47	0.48	0.54	0.58	0.44
Ca	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
Fo	77.42	77.40	77.54	72.49	71.92	77.32	76.16	76.34	72.97	71.11	78.10
Fa	22.50	22.53	22.35	27.44	28.04	22.56	23.66	23.50	26.98	28.77	21.81

[1]based on 4 oxygens

Appendix E

E:3 Composition of olivine phenocrysts from LW40FVP of Ql2a

Point	lw40fvp#4c	lw40fvp#4d	lw40fvp#4e	lw40fvp#4f	lw40fvp#4g	lw40fvp#4h	lw40fvp#5b	lw40fvp#5	lw40fvp#5	lw40fvp#5	lw40fvp#5
SiO_2	38.20	38.36	38.04	38.25	38.31	36.95	37.48	37.88	37.85	38.03	38.05
MgO	40.99	40.58	41.02	40.98	40.76	35.29	38.18	40.57	40.14	40.55	41.02
FeO	19.97	21.03	20.52	20.07	20.43	26.98	23.30	20.83	21.18	21.00	20.53
CaO	0.15	0.16	0.13	0.14	0.12	0.28	0.14	0.15	0.15	0.14	0.13
MnO	0.23	0.29	0.22	0.29	0.27	0.45	0.33	0.25	0.22	0.26	0.23
NiO	0.20	0.22	0.22	0.30	0.25	0.07	0.15	0.24	0.28	0.34	0.21
TOTAL	99.74	100.63	100.16	100.03	100.13	100.01	99.58	99.92	99.82	100.32	100.16
Cations[1]											
Si	0.99	0.99	0.98	0.99	0.99	0.99	0.99	0.98	0.98	0.98	0.98
Mg	1.58	1.56	1.58	1.58	1.57	1.41	1.50	1.57	1.56	1.56	1.58
Fe	0.43	0.45	0.44	0.43	0.44	0.60	0.51	0.45	0.46	0.45	0.44
Ca	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00
Fo	78.49	77.40	78.03	78.34	77.96	69.91	74.37	77.59	77.13	77.42	78.02
Fa	21.45	22.51	21.91	21.53	21.92	29.98	25.46	22.35	22.83	22.50	21.90

[1]based on 4 oxygens

Appendix E

E:3 Composition of olivine phenocrysts from LW40FVP of Ql2a

Point	lw40fvp#5	lw40fvp#5e	lw40fvp#6a	lw40fvp#6b	lw40fvp#6c	lw40fvp#6d
SiO_2	38.71	37.14	36.67	36.86	38.10	38.20
MgO	40.83	38.53	34.90	35.54	40.65	40.59
FeO	20.16	23.43	27.72	26.28	20.48	20.53
CaO	0.11	0.16	0.30	0.24	0.12	0.15
MnO	0.27	0.34	0.45	0.45	0.27	0.24
NiO	0.21	0.13	0.08	0.08	0.26	0.25
TOTAL	100.30	99.72	100.13	99.44	99.87	99.96
Cations[1]						
Si	1.00	0.98	0.98	0.99	0.99	0.99
Mg	1.56	1.51	1.39	1.42	1.57	1.57
Fe	0.43	0.52	0.62	0.59	0.44	0.44
Ca	0.00	0.01	0.01	0.01	0.00	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.00	0.00	0.00	0.01	0.01
Fo	78.19	74.45	69.12	70.56	77.87	77.86
Fa	21.67	25.40	30.80	29.27	22.01	22.09

[1]based on 4 oxygens

Appendix E

E:4 Composition of olivine phenocrysts from LW135FVP of Qs2fs

Point	lw135_1b	lw135_1	lw135_1	lw135_1	lw135_1	lw135_1	lw135_1	lw135_1	lw135_1	lw135_1	lw135_1	lw135_1e
SiO_2	38.31	38.59	38.34	38.38	39.05	38.31	38.18	38.57	38.44	38.41	38.32	38.14
Cr_2O_3	0.00	0.01	0.01	0.05	0.03	0.02	0.00	0.01	0.01	0.00	0.00	0.01
FeO	21.94	21.54	21.87	21.87	21.80	22.03	22.18	22.07	21.90	21.05	21.52	22.56
MgO	39.42	39.59	39.74	39.56	39.57	39.50	39.73	39.51	39.71	39.31	39.71	39.26
MnO	0.38	0.27	0.31	0.30	0.27	0.30	0.29	0.31	0.27	0.29	0.30	0.40
CaO	0.18	0.15	0.14	0.13	0.13	0.15	0.16	0.14	0.13	0.17	0.17	0.15
NiO	0.16	0.25	0.22	0.26	0.25	0.08	0.22	0.21	0.19	0.18	0.19	0.13
TOTAL	100.39	100.39	100.63	100.54	101.11	100.38	100.76	100.82	100.65	99.40	100.21	100.65.
Cations[1]												
Si	0.99	1.00	0.99	0.99	1.00	0.99	0.99	1.00	0.99	1.00	0.99	0.99
Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.48	0.47	0.47	0.47	0.47	0.48	0.48	0.48	0.47	0.46	0.47	0.49
Mg	1.52	1.53	1.53	1.53	1.51	1.53	1.53	1.52	1.53	1.53	1.53	1.52
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ca	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00
Ni	0.00	0.01	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Fo	76.07	76.55	76.29	76.21	76.30	76.07	76.08	76.03	76.27	76.84	76.61	75.44
Fa	23.76	23.37	23.56	23.64	23.59	23.81	23.83	23.83	23.61	23.08	23.29	24.33

[1]based on 4 oxygens

Appendix E

E:4 Composition of olivine phenocrysts from LW135FVP of Qs2fs

Point	lw135_4ab	lw135_4a	lw135_4a	lw135_4a	lw135_4a	lw135_4a	lw135_4a	lw135_4a	lw135_4a	lw135_4a	lw135_4ae
SiO_2	38.05	38.39	38.26	38.73	38.92	38.65	38.27	38.09	38.01	38.13	38.31
Cr_2O_3	0.00	0.01	0.01	0.02	0.02	0.00	0.00	0.14	0.02	0.01	0.02
FeO	21.00	20.69	20.52	20.88	20.83	20.85	20.69	21.34	20.72	20.86	21.14
MgO	39.28	39.96	39.89	39.95	40.13	40.01	38.92	39.87	40.09	39.91	39.33
MnO	0.31	0.27	0.32	0.28	0.24	0.24	0.22	0.22	0.31	0.27	0.28
CaO	0.20	0.17	0.14	0.13	0.13	0.15	0.15	0.14	0.13	0.17	0.17
NiO	0.04	0.22	0.17	0.24	0.20	0.17	0.26	0.19	0.23	0.18	0.11
TOTAL	98.87	99.70	99.30	100.24	100.48	100.07	98.50	99.99	99.52	99.53	99.34
Cations[1]											
Si	1.00	1.00	1.00	1.00	1.00	1.00	1.01	0.99	0.99	0.99	1.00
Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.46	0.45	0.45	0.45	0.45	0.45	0.45	0.46	0.45	0.45	0.46
Mg	1.53	1.55	1.55	1.54	1.54	1.54	1.52	1.54	1.56	1.55	1.53
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ca	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Ni	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.00
Fo	76.87	77.44	77.49	77.22	77.39	77.33	77.00	76.87	77.40	77.28	76.77
Fa	23.06	22.50	22.36	22.65	22.54	22.61	22.97	23.09	22.45	22.67	23.16

[1]based on 4 oxygens

Appendix E

E:4 Composition of olivine phenocrysts from LW135FVP of Qs2fs

Point	lw135_5b	lw135_5	lw135_5	lw135_5	lw135_5	lw135_5	lw135_5	lw135_5	lw135_5	lw135_5	lw135_5
SiO_2	38.52	38.63	38.36	38.40	38.46	38.48	38.46	38.50	38.30	38.63	38.42
Cr_2O_3	0.00	0.00	0.01	0.00	0.01	0.01	0.02	0.04	0.00	0.00	0.00
FeO	20.53	20.64	20.51	20.24	20.33	20.56	20.12	20.57	20.37	20.26	20.57
MgO	40.14	40.05	39.97	40.14	39.96	40.01	40.00	39.96	39.91	39.81	39.95
MnO	0.22	0.30	0.26	0.25	0.25	0.23	0.21	0.27	0.28	0.28	0.24
CaO	0.16	0.15	0.16	0.14	0.15	0.16	0.16	0.14	0.17	0.14	0.18
NiO	0.19	0.20	0.19	0.22	0.18	0.23	0.24	0.12	0.23	0.27	0.24
TOTAL	99.76	99.97	99.46	99.39	99.34	99.69	99.21	99.61	99.26	99.39	99.60
Cations[1]											
Si	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe	0.44	0.45	0.45	0.44	0.44	0.45	0.44	0.45	0.44	0.44	0.45
Mg	1.55	1.54	1.55	1.55	1.55	1.55	1.55	1.54	1.55	1.54	1.55
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ca	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.01
Ni	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.01
Fo	77.68	77.48	77.59	77.89	77.73	77.60	77.99	77.51	77.69	77.70	77.57
Fa	22.29	22.40	22.34	22.04	22.19	22.37	22.01	22.39	22.24	22.19	22.41

[1]based on 4 oxygens

Appendix E

E:5 Composition of olivine phenocrysts from LW61FVP of Ql3

Point	lw61fvp_#1a	lw61fvp_#1b	lw61fvp_#1c	lw61fvp_#1d	lw61fvp_#1e	lw61fvp_#1f	lw61fvp_#1g	lw61fvp_#2a	lw61fvp_#2b
SiO_2	37.13	38.13	38.11	38.07	38.35	36.97	36.96	37.15	38.10
MgO	36.62	40.85	40.97	40.91	40.88	36.08	35.66	36.44	41.14
FeO	25.00	20.27	20.33	20.14	20.22	26.33	26.51	25.44	20.30
CaO	0.17	0.11	0.14	0.13	0.12	0.23	0.28	0.22	0.11
MnO	0.41	0.28	0.25	0.32	0.26	0.40	0.42	0.43	0.27
NiO	0.09	0.21	0.21	0.24	0.25	0.10	0.11	0.09	0.22
TOTAL	99.42	99.86	100.00	99.81	100.07	100.11	99.93	99.77	100.14
Cations[1]									
Si	0.99	0.99	0.99	0.99	0.99	0.98	0.99	0.99	0.98
Mg	1.45	1.58	1.58	1.58	1.57	1.43	1.42	1.44	1.58
Fe	0.56	0.44	0.44	0.44	0.44	0.59	0.59	0.57	0.44
Ca	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01
Fo	72.15	78.11	78.17	78.22	78.19	70.86	70.51	71.74	78.20
Fa	27.64	21.75	21.76	21.61	21.70	29.01	29.42	28.11	21.66

[1]based on 4 oxygens

Appendix E

E:5 Composition of olivine phenocrysts from LW61FVP of Ql3

Point	lw61fvp_#2c	lw61fvp_-#2d	lw61fvp_#2e	lw61fvp_#2f	lw61fvp_#2g	lw61fvp_#2h	lw61fvp_#2i	lw61fvp_#2j	lw61fvp_#2k
SiO_2	38.18	38.39	38.24	37.67	38.15	38.17	38.12	38.17	37.04
MgO	41.02	40.80	40.53	38.04	40.95	40.99	40.79	40.32	36.09
FeO	20.33	20.30	21.23	23.36	20.33	20.59	20.56	21.09	25.79
CaO	0.14	0.16	0.14	0.18	0.13	0.13	0.13	0.12	0.24
MnO	0.29	0.31	0.29	0.36	0.26	0.27	0.24	0.28	0.41
NiO	0.20	0.30	0.23	0.13	0.28	0.22	0.28	0.24	0.11
TOTAL	100.15	100.26	100.66	99.74	100.10	100.37	100.11	100.22	99.67
Cations[1]									
Si	0.99	0.99	0.99	0.99	0.99	0.98	0.99	0.99	0.99
Mg	1.58	1.57	1.56	1.49	1.58	1.58	1.57	1.55	1.43
Fe	0.44	0.44	0.46	0.51	0.44	0.44	0.44	0.46	0.58
Ca	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00
Fo	78.14	78.09	77.20	74.27	78.13	77.93	77.89	77.21	71.30
Fa	21.73	21.80	22.69	25.59	21.76	21.96	22.03	22.66	28.59

[1]based on 4 oxygens

Appendix E

E:5 Composition of olivine phenocrysts from LW61FVP of Ql3

Point	lw61fvp_#3a	lw61fvp_#3b	lw61fvp_#3c	lw61fvp_#3d	lw61fvp_#3e	lw61fvp_#4a	lw61fvp_#4b	lw61fvp_#4c	lw61fvp_#4d
SiO_2	37.43	38.23	38.17	38.00	37.10	37.00	38.04	38.19	38.04
MgO	36.11	40.60	40.98	40.23	35.91	36.21	40.70	40.71	40.68
FeO	25.98	20.84	20.74	21.53	26.44	26.46	20.80	20.96	20.81
CaO	0.24	0.16	0.13	0.15	0.23	0.25	0.14	0.15	0.12
MnO	0.39	0.27	0.25	0.27	0.39	0.43	0.33	0.25	0.31
NiO	0.13	0.20	0.21	0.22	0.09	0.06	0.22	0.19	0.25
TOTAL	100.27	100.31	100.48	100.40	100.16	100.40	100.23	100.44	100.20
Cations[1]									
Si	0.99	0.99	0.98	0.98	0.99	0.98	0.98	0.99	0.98
Mg	1.43	1.56	1.57	1.55	1.42	1.43	1.57	1.57	1.57
Fe	0.58	0.45	0.45	0.47	0.59	0.59	0.45	0.45	0.45
Ca	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01
Fo	71.17	77.58	77.82	76.84	70.69	70.83	77.58	77.53	77.57
Fa	28.73	22.35	22.10	23.07	29.20	29.04	22.25	22.40	22.26

[1]based on 4 oxygens

Appendix E

E:5 Composition of olivine phenocrysts from LW61FVP of Ql3

Point	lw61fvp_#4e	lw61fvp_#4f	lw61fvp_#4g	lw61fvp_#4h	lw61fvp_#4i	lw61fvp_#4j	lw61fvp_#4k	lw61fvp_#4l	lw61fvp_#4m
SiO_2	37.38	37.25	38.19	38.14	37.43	37.93	36.91	37.90	38.24
MgO	37.82	36.80	40.60	40.55	37.28	40.13	34.82	39.86	40.46
FeO	23.76	25.24	20.89	20.96	24.87	21.11	27.21	21.73	20.56
CaO	0.17	0.21	0.18	0.14	0.18	0.21	0.28	0.15	0.12
MnO	0.31	0.43	0.29	0.26	0.36	0.21	0.47	0.32	0.24
NiO	0.18	0.08	0.23	0.20	0.24	0.20	0.07	0.15	0.15
TOTAL	99.62	100.00	100.36	100.24	100.35	99.79	99.75	100.12	99.77
Cations[1]									
Si	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Mg	1.49	1.45	1.56	1.56	1.46	1.56	1.39	1.54	1.56
Fe	0.52	0.56	0.45	0.45	0.55	0.46	0.61	0.47	0.45
Ca	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
Fo	73.86	72.08	77.55	77.45	72.66	77.27	69.43	76.47	77.75
Fa	26.03	27.74	22.39	22.46	27.20	22.80	30.44	23.39	22.16

[1]based on 4 oxygens

Appendix E

E:5 Composition of olivine phenocrysts from LW61FVP of Q13

Point	lw61fvp_#4n	lw61fvp_#5a	lw61fvp_#5b	lw61fvp_#5c	lw61fvp_#5d	lw61fvp_#5e	lw61fvp_#5f	lw61fvp_#5g	lw61fvp_#5h
SiO_2	37.24	36.71	37.93	38.26	37.52	36.47	36.49	38.04	38.09
MgO	35.69	34.71	39.79	40.36	37.40	34.95	35.40	41.27	41.03
FeO	26.22	27.34	21.50	21.17	24.33	27.20	26.86	20.11	20.23
CaO	0.26	0.32	0.15	0.14	0.19	0.28	0.26	0.13	0.10
MnO	0.37	0.48	0.29	0.32	0.34	0.46	0.41	0.26	0.23
NiO	0.09	0.07	0.23	0.19	0.18	0.05	0.01	0.20	0.28
TOTAL	99.87	99.63	99.89	100.42	99.97	99.41	99.43	100.01	99.96
Cations[1]									
Si	0.99	0.99	0.99	0.99	0.99	0.98	0.98	0.98	0.98
Mg	1.42	1.39	1.54	1.55	1.47	1.40	1.42	1.59	1.58
Fe	0.58	0.61	0.47	0.46	0.54	0.61	0.60	0.43	0.44
Ca	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01
Fo	70.78	69.29	76.64	77.14	73.17	69.52	70.08	78.45	78.25
Fa	29.18	30.62	23.24	22.70	26.71	30.36	29.83	21.45	21.65

[1]based on 4 oxygens

Appendix E

E:5 Composition of olivine phenocrysts from LW61FVP of Ql3

Point	lw61fvp_#5i	lw61fvp_#5j
SiO_2	38.16	36.84
MgO	39.91	36.25
FeO	21.43	26.26
CaO	0.16	0.20
MnO	0.29	0.38
NiO	0.14	0.11
TOTAL	100.08	100.05
Cations[1]		
Si	0.99	0.98
Mg	1.54	1.44
Fe	0.47	0.58
Ca	0.00	0.01
Mn	0.01	0.01
Ni	0.00	0.00
Fo	76.77	71.01
Fa	23.13	28.86

[1]based on 4 oxygens

Appendix E

E:6 Composition of olivine phenocrysts from LW80FVP of Qs3

Point	lw80fvp_rim_#1a	lw80fvp_core_#1f	lw80fvp_core_#1e	lw80fvp_rim_#1d	lw80fvp_rim_#1c	lw80fvp_rim_#2a	lw80fvp_core_#2e
SiO_2	37.61	38.46	38.26	38.32	38.22	38.58	38.25
MgO	39.72	40.46	40.44	40.22	40.63	40.29	40.08
FeO	21.45	20.92	20.93	20.72	21.09	20.82	21.92
CaO	0.16	0.16	0.15	0.15	0.16	0.16	0.13
MnO	0.30	0.33	0.29	0.27	0.27	0.31	0.33
NiO	0.07	0.22	0.25	0.14	0.21	0.14	0.20
TOTAL	99.31	100.54	100.32	99.82	100.58	100.29	100.91
Cations[1]							
Si	0.98	0.99	0.99	0.99	0.99	1.00	0.99
Mg	1.55	1.55	1.56	1.55	1.56	1.55	1.54
Fe	0.47	0.45	0.45	0.45	0.46	0.45	0.47
Ca	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.01	0.01	0.00	0.00	0.00	0.00
Fo	76.66	77.40	77.41	77.51	77.38	77.43	76.39
Fa	23.22	22.45	22.48	22.41	22.54	22.45	23.44

[1]based on 4 oxygens

Appendix E

E:6 Composition of olivine phenocrysts from LW80FVP of Qs3

Point	lw80fvp_core_#2d	lw80fvp_rim_#2b	lw80fvp_rim_#2f	lw80fvp_core_#2h	lw80fvp_core_#2i	lw80fvp_rim_#2g	lw80fvp_rim_#3a
SiO_2	37.27	37.57	37.89	37.75	37.52	37.91	37.96
MgO	40.16	40.40	40.25	39.68	39.34	39.63	40.66
FeO	21.13	21.10	21.26	22.14	22.24	21.59	21.03
CaO	0.15	0.17	0.14	0.13	0.13	0.14	0.14
MnO	0.26	0.27	0.29	0.35	0.29	0.28	0.30
NiO	0.13	0.18	0.20	0.14	0.15	0.16	0.20
TOTAL	99.08	99.69	100.02	100.19	99.67	99.70	100.30
Cations[1]							
Si	0.98	0.98	0.98	0.98	0.98	0.99	0.98
Mg	1.57	1.57	1.56	1.54	1.54	1.54	1.57
Fe	0.46	0.46	0.46	0.48	0.49	0.47	0.46
Ca	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fo	77.15	77.29	77.05	76.01	75.82	76.50	77.40
Fa	22.78	22.65	22.83	23.79	24.04	23.38	22.47

[1]based on 4 oxygens

Appendix E

E:6 Composition of olivine phenocrysts from LW80FVP of Qs3

Point	lw80fvp_core_#3g	lw80fvp_core_#3e	lw80fvp_rim_#3d	lw80fvp_rim_#3c	lw80fvp_rim_#4a	lw80fvp_core_#4d	lw80fvp_core_#4c
SiO_2	38.45	37.89	38.54	37.76	37.45	38.19	38.32
MgO	41.02	40.72	40.62	40.29	40.17	40.91	40.98
FeO	20.11	20.44	20.82	21.03	21.16	20.44	20.45
CaO	0.11	0.14	0.16	0.14	0.17	0.11	0.13
MnO	0.27	0.25	0.29	0.29	0.30	0.23	0.24
NiO	0.23	0.24	0.14	0.13	0.17	0.22	0.22
TOTAL	100.19	99.68	100.57	99.63	99.42	100.10	100.35
Cations[1]							
Si	0.99	0.98	0.99	0.98	0.98	0.99	0.99
Mg	1.57	1.58	1.56	1.56	1.57	1.57	1.57
Fe	0.43	0.44	0.45	0.46	0.46	0.44	0.44
Ca	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.01	0.01	0.00	0.00	0.00	0.01	0.01
Fo	78.31	77.95	77.59	77.25	77.11	78.03	78.07
Fa	21.54	21.96	22.31	22.62	22.79	21.87	21.85

[1]based on 4 oxygens

Appendix E

E:6 Composition of olivine phenocrysts from LW80FVP of Qs3

Point	lw80fvp_rim_#4b	lw80fvp_rim_#5b	lw80fvp_core_#5d	lw80fvp_core_#5e	lw80fvp_rim_#5a	lw80fvp_rim_#5c
SiO_2	37.81	37.47	38.33	38.24	37.64	38.57
MgO	40.90	39.85	41.20	40.79	40.29	40.48
FeO	20.37	21.26	20.00	20.36	21.32	20.89
CaO	0.12	0.17	0.13	0.11	0.14	0.14
MnO	0.28	0.29	0.19	0.28	0.30	0.30
NiO	0.21	0.16	0.24	0.23	0.15	0.15
TOTAL	99.69	99.20	100.08	100.01	99.84	100.53
Cations[1]						
Si	0.98	0.98	0.99	0.99	0.98	0.99
Mg	1.58	1.56	1.58	1.57	1.56	1.55
Fe	0.44	0.47	0.43	0.44	0.46	0.45
Ca	0.00	0.01	0.00	0.00	0.00	0.00
Mn	0.01	0.01	0.00	0.01	0.01	0.01
Ni	0.00	0.00	0.01	0.01	0.00	0.00
Fo	78.06	76.90	78.57	78.00	77.01	77.45
Fa	21.81	23.02	21.40	21.85	22.86	22.42

[1]based on 4 oxygens

Appendix E

E:7 Composition of olivine phenocrysts from LW78FVP of Qs4b

Point	lw78fvp_rim_#1b	lw78fvp_core_#1c	lw78fvp_core_#1d	lw78fvp_rim_#1a	lw78fvp_rim_#2a	lw78fvp_rim_#2c	lw78fvp_core_#2d
SiO_2	37.86	38.10	37.98	38.03	37.96	37.96	37.92
MgO	39.78	40.45	40.86	40.37	40.26	39.89	40.30
FeO	20.81	20.24	20.44	20.26	20.28	20.99	20.33
CaO	0.14	0.15	0.13	0.15	0.15	0.16	0.15
MnO	0.28	0.29	0.22	0.24	0.22	0.27	0.23
NiO	0.15	0.26	0.24	0.14	0.16	0.15	0.16
TOTAL	99.03	99.49	99.86	99.19	99.03	99.42	99.08
Cations[1]							
Si	0.99	0.99	0.98	0.99	0.99	0.99	0.99
Mg	1.55	1.57	1.58	1.57	1.57	1.55	1.57
Fe	0.46	0.44	0.44	0.44	0.44	0.46	0.44
Ca	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.01	0.01	0.00	0.00	0.00	0.00
Fo	77.22	78.00	78.04	77.99	77.95	77.15	77.91
Fa	22.67	21.89	21.90	21.95	22.03	22.78	22.05

[1]based on 4 oxygen

Appendix E

E:7 Composition of olivine phenocrysts from LW78FVP of Qs4b

Point	lw78fvp_core_#2f	lw78fvp_core_#2e	lw78fvp_rim_#2b	lw78fvp_rim_#3f	lw78fvp_#3g	lw78fvp_#3h	lw78fvp_#3i	lw78fvp_rim_#3j
SiO_2	37.79	39.07	37.58	37.04	37.01	38.34	37.60	37.33
MgO	40.90	41.80	39.49	39.42	39.74	40.80	40.27	39.50
FeO	20.60	21.03	21.34	21.48	21.38	20.57	20.66	21.26
CaO	0.14	0.14	0.21	0.19	0.18	0.13	0.13	0.18
MnO	0.24	0.24	0.25	0.22	0.27	0.25	0.27	0.27
NiO	0.23	0.32	0.14	0.11	0.06	0.18	0.26	0.11
TOTAL	99.90	102.61	99.00	98.46	98.64	100.26	99.19	98.65
Cations[1]								
Si	0.98	0.99	0.99	0.98	0.98	0.99	0.98	0.98
Mg	1.58	1.57	1.55	1.55	1.56	1.57	1.57	1.55
Fe	0.45	0.44	0.47	0.48	0.47	0.44	0.45	0.47
Ca	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00
Fo	77.91	77.94	76.76	76.60	76.79	77.88	77.56	76.78
Fa	22.01	22.00	23.27	23.42	23.18	22.03	22.33	23.18

[1]based on 4 oxygen

Appendix E

E:7 Composition of olivine phenocrysts from LW78FVP of Qs4b

Point	lw78fvp_rim_#3k	lw78fvp_rim_#3l	lw78fvp_rim_#4a	lw78fvp_rim_#4b	lw78fvp_core_#4f	lw78fvp_core_#4d	lw78fvp_core_#4h
SiO_2	37.39	37.27	36.82	38.04	38.94	38.04	37.71
MgO	39.68	39.39	39.96	40.29	41.60	40.62	40.74
FeO	21.29	21.82	20.83	20.58	20.80	20.11	20.25
CaO	0.17	0.18	0.16	0.14	0.15	0.15	0.13
MnO	0.27	0.27	0.26	0.30	0.22	0.27	0.26
NiO	0.28	0.09	0.20	0.21	0.30	0.28	0.20
TOTAL	99.09	99.01	98.22	99.56	102.01	99.46	99.30
Cations[1]							
Si	0.98	0.98	0.97	0.99	0.99	0.99	0.98
Mg	1.55	1.55	1.58	1.56	1.57	1.57	1.58
Fe	0.47	0.48	0.46	0.45	0.44	0.44	0.44
Ca	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.01	0.00	0.00	0.00	0.01	0.01	0.00
Fo	76.81	76.25	77.32	77.62	78.07	78.19	78.12
Fa	23.13	23.70	22.61	22.24	21.90	21.72	21.78

[1]based on 4 oxygen

Appendix E

E:7 Composition of olivine phenocrysts from LW78FVP of Qs4b

Point	lw78fvp_rim_#4c	lw78fvp_rim_#5a	lw78fvp_rim_#5c	lw78fvp_core_#5e	lw78fvp_core_#5d	lw78fvp_core_#5f	lw78fvp_rim_#5b
SiO_2	37.69	37.59	38.20	38.22	38.26	38.18	37.93
MgO	40.18	39.89	40.18	40.76	40.52	40.88	40.36
FeO	20.93	21.22	21.08	20.33	20.71	20.45	21.11
CaO	0.16	0.16	0.16	0.09	0.14	0.10	0.15
MnO	0.22	0.29	0.33	0.27	0.28	0.33	0.22
NiO	0.12	0.11	0.20	0.26	0.25	0.29	0.21
TOTAL	99.29	99.25	100.14	99.92	100.16	100.24	99.96
Cations[1]							
Si	0.98	0.98	0.99	0.99	0.99	0.99	0.98
Mg	1.56	1.56	1.55	1.57	1.56	1.57	1.56
Fe	0.46	0.46	0.46	0.44	0.45	0.44	0.46
Ca	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mn	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.00	0.00	0.00	0.01	0.01	0.01	0.00
Fo	77.37	76.94	77.15	78.00	77.63	77.92	77.28
Fa	22.61	22.96	22.71	21.83	22.26	21.87	22.68

[1]based on 4 oxygen

Appendix E

E:8 Composition of olivine phenocrysts from LW151FVP of Qs4a

Point	lw151fvp#1b	lw151fvp#1	lw151fvp#1	lw151fvp#1	lw151fvp#1	lw151fvp#1	lw151fvp#1e	lw151fvp#2b	lw151fvp#2	lw151fvp#2
SiO_2	38.14	37.94	37.87	37.69	38.06	37.83	38.42	38.05	38.60	38.22
MgO	40.52	40.37	39.89	39.62	40.02	40.70	40.59	39.54	40.50	40.79
FeO	20.41	20.27	20.78	21.22	21.25	20.42	20.38	21.88	20.99	20.42
CaO	0.13	0.14	0.15	0.12	0.14	0.13	0.13	0.18	0.18	0.12
MnO	0.16	0.35	0.22	0.24	0.27	0.23	0.18	0.34	0.24	0.26
NiO	0.24	0.22	0.09	0.24	0.15	0.25	0.27	0.09	0.21	0.20
TOTAL	99.60	99.27	99.00	99.14	99.88	99.57	99.98	100.07	100.71	100.01
Cations[1]										
Si	0.99	0.99	0.99	0.99	0.99	0.98	0.99	0.99	0.99	0.99
Mg	1.57	1.57	1.55	1.55	1.55	1.58	1.56	1.53	1.55	1.57
Fe	0.44	0.44	0.45	0.47	0.46	0.44	0.44	0.48	0.45	0.44
Ca	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00
Mn	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01
Ni	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00
Fo	77.96	77.86	77.36	76.82	76.97	77.97	78.01	76.22	77.46	77.98
Fa	22.03	21.94	22.61	23.08	22.93	21.95	21.98	23.67	22.52	21.91

[1]based on 4 oxygens

Appendix E

E:8 Composition of olivine phenocrysts from LW151FVP of Qs4a

Point	lw151fvp#2	lw151fvp#2	lw151fvp#2	lw151fvp#2e	lw151fvp#3b	lw151fvp#3	lw151fvp#3	lw151fvp#3	lw151fvp#3	lw151fvp#3
SiO_2	38.17	38.65	38.06	38.26	38.32	38.13	38.32	38.14	38.46	39.04
MgO	40.74	40.59	40.83	39.87	39.44	39.66	40.20	39.43	38.50	38.54
FeO	20.40	20.62	20.54	21.12	21.47	21.04	21.09	21.56	21.63	21.41
CaO	0.12	0.15	0.15	0.18	0.15	0.19	0.15	0.13	0.15	0.14
MnO	0.21	0.20	0.29	0.37	0.23	0.32	0.30	0.32	0.30	0.34
NiO	0.24	0.30	0.23	0.18	0.14	0.15	0.13	0.19	0.18	0.13
TOTAL	99.87	100.51	100.09	99.98	99.75	99.48	100.19	99.77	99.22	99.60
Cations[1]										
Si	0.99	0.99	0.98	0.99	1.00	0.99	0.99	0.99	1.01	1.01
Mg	1.57	1.56	1.57	1.54	1.53	1.54	1.55	1.53	1.50	1.49
Fe	0.44	0.44	0.44	0.46	0.47	0.46	0.46	0.47	0.47	0.47
Ca	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
Mn	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fo	78.02	77.82	77.91	76.97	76.57	77.01	77.16	76.40	75.95	76.09
Fa	21.92	22.17	21.99	22.88	23.39	22.92	22.72	23.43	23.93	23.72

[1]based on 4 oxygens

Appendix E

E:8 Composition of olivine phenocrysts from LW151FVP of Qs4a

Point	lw151fvp#3e	lw151fvp#4b	lw151fvp#4	lw151fvp#4	lw151fvp#4e	lw151fvp#5b	lw151fvp#5	lw151fvp#5	lw151fvp#5e
SiO_2	38.34	37.84	37.92	37.94	37.95	38.86	38.66	38.94	38.77
MgO	39.62	40.59	40.80	40.77	40.67	40.50	40.83	40.80	41.23
FeO	20.49	19.93	20.27	20.43	20.48	20.54	20.33	20.37	20.19
CaO	0.14	0.12	0.12	0.15	0.14	0.17	0.16	0.14	0.13
MnO	0.29	0.21	0.24	0.20	0.27	0.29	0.22	0.30	0.21
NiO	0.22	0.29	0.24	0.29	0.23	0.28	0.22	0.30	0.32
TOTAL	99.10	98.96	99.60	99.78	99.74	100.65	100.41	100.83	100.86
Cations[1]									
Si	1.00	0.99	0.98	0.98	0.98	1.00	0.99	1.00	0.99
Mg	1.54	1.58	1.58	1.58	1.57	1.55	1.56	1.56	1.57
Fe	0.45	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.43
Ca	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Mn	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01
Ni	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Fo	77.41	78.35	78.13	78.05	77.90	77.78	78.14	78.02	78.41
Fa	22.47	21.58	21.78	21.94	22.01	22.14	21.83	21.85	21.54

[1]based on 4 oxygens

Appendix E

E:9 Composition of plagioclase phenocrysts and groundmass (gm) from LW21FVP of Ql1d

Point	lw21_#3b	lw21_#3	lw21_#3	lw21_#3e	lw21_#7b	lw21_#7	lw21_#7	lw21_#7e	lw21_#10b	lw21_#10	lw21_#10	lw21_#10
SiO_2	51.06	49.45	49.88	50.60	51.98	51.07	48.69	50.37	49.49	49.05	49.50	50.11
Al_2O_3	29.09	30.61	30.49	29.59	29.79	30.65	29.36	29.67	30.07	30.20	30.06	30.28
FeO	0.82	0.69	0.83	0.79	0.76	0.73	0.73	0.81	0.82	0.67	0.68	0.74
CaO	12.63	14.04	14.10	12.99	12.67	13.52	14.57	13.13	13.72	13.83	13.66	13.86
Na_2O	4.21	3.40	3.56	4.04	4.38	3.79	3.63	3.79	3.57	3.55	3.58	3.52
K_2O	0.32	0.21	0.22	0.31	0.36	0.23	0.26	0.29	0.25	0.24	0.23	0.23
SrO	0.33	0.32	0.39	0.31	0.29	0.33	0.32	0.35	0.42	0.34	0.27	0.30
BaO	0.11	0.01	0.11	0.11	0.08	0.06	0.08	0.07	0.06	0.06	0.03	0.07
TOTAL	98.55	98.72	99.57	98.73	100.30	100.39	97.64	98.48	98.40	97.95	98.01	99.11
Cations[1]												
Si	2.37	2.30	2.30	2.35	2.37	2.33	2.30	2.34	2.31	2.30	2.31	2.32
Al	1.59	1.68	1.66	1.62	1.60	1.65	1.63	1.63	1.65	1.67	1.66	1.65
Fe	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Ca	0.63	0.70	0.70	0.65	0.62	0.66	0.74	0.65	0.69	0.70	0.68	0.69
Na	0.38	0.31	0.32	0.36	0.39	0.34	0.33	0.34	0.32	0.32	0.32	0.32
K	0.02	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.01	0.01
Sr	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Or	1.87	1.24	1.26	1.78	2.03	1.35	1.42	1.68	1.44	1.41	1.36	1.32
Ab	36.86	30.07	30.89	35.33	37.63	33.17	30.58	33.65	31.55	31.23	31.70	31.04
An	61.08	68.67	67.66	62.71	60.19	65.37	67.86	64.53	66.90	67.25	66.90	67.51

[1]based on 8 oxygens

Appendix E

E:9 Composition of plagioclase phenocrysts and groundmass (gm) from LW21FVP of Ql1d

Point	lw21_#10e	lw21_#11ab	lw21_#11a	lw21_#11ae	lw21_#11bb	lw21_#11b	lw21_#11b	lw21_#11b	lw21_#11be	lw21_#12ab
SiO_2	50.55	57.42	50.44	49.76	49.33	49.84	50.35	50.33	50.55	48.34
Al_2O_3	30.01	23.69	29.92	29.44	29.21	30.06	29.96	29.74	29.55	29.21
FeO	0.87	0.62	0.73	0.80	0.74	0.66	0.58	0.66	0.76	0.93
CaO	13.36	6.65	13.57	13.01	13.77	13.77	13.49	13.60	12.79	13.69
Na_2O	3.76	5.87	3.64	4.02	3.80	3.62	3.64	3.64	4.11	3.79
K_2O	0.27	3.24	0.26	0.32	0.29	0.23	0.23	0.25	0.32	0.32
SrO	0.39	0.11	0.37	0.29	0.31	0.27	0.37	0.29	0.31	0.31
BaO	0.13	0.28	0.12	0.10	0.07	0.04	0.07	0.07	0.00	0.04
TOTAL	99.33	97.89	99.04	97.73	97.52	98.49	98.68	98.56	98.39	96.63
Cations[1]										
Si	2.33	2.67	2.33	2.34	2.33	2.32	2.34	2.34	2.35	2.30
Al	1.63	1.30	1.63	1.63	1.62	1.65	1.64	1.63	1.62	1.64
Fe	0.03	0.02	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.04
Ca	0.66	0.33	0.67	0.65	0.70	0.69	0.67	0.68	0.64	0.70
Na	0.34	0.53	0.33	0.37	0.35	0.33	0.33	0.33	0.37	0.35
K	0.02	0.19	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02
Sr	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ba	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Or	1.55	18.15	1.50	1.82	1.63	1.35	1.35	1.43	1.82	1.80
Ab	33.14	50.04	32.09	35.15	32.74	31.78	32.31	32.11	36.08	32.72
An	65.08	31.33	66.20	62.85	65.51	66.82	66.23	66.33	62.09	65.40

[1]based on 8 oxygens

Appendix E

E:9 Composition of plagioclase phenocrysts and groundmass (gm) from LW21FVP of Ql1d

Point	lw21_#12a	lw21_#12a	lw21_#12a	lw21_#12ae	lw21_#12bb	lw21_#12b	lw21_#12b	lw21_#12be	lw21_#13b gm	lw21_#13 gm	lw21_#13 gm
SiO_2	48.24	48.70	48.29	50.84	50.36	48.67	49.07	50.23	48.57	48.40	48.86
Al_2O_3	30.33	30.40	30.30	29.77	30.22	30.07	30.37	29.12	29.65	29.97	29.63
FeO	0.71	0.70	0.78	0.81	0.77	0.65	0.68	0.81	0.77	0.70	0.74
CaO	13.63	13.68	13.92	12.96	13.69	14.32	13.93	12.42	13.29	13.51	13.41
Na_2O	3.57	3.52	3.52	3.89	3.59	3.47	3.59	4.25	3.64	3.69	3.65
K_2O	0.24	0.22	0.26	0.30	0.25	0.24	0.24	0.38	0.27	0.24	0.32
SrO	0.34	0.24	0.31	0.33	0.36	0.31	0.38	0.34	0.46	0.33	0.33
BaO	0.08	0.02	0.08	0.08	0.07	0.05	0.07	0.11	0.08	0.05	0.10
TOTAL	97.14	97.47	97.46	98.99	99.31	97.77	98.31	97.67	96.72	96.88	97.03
Cations[1]											
Si	2.28	2.29	2.28	2.35	2.32	2.29	2.29	2.36	2.31	2.29	2.31
Al	1.69	1.69	1.69	1.62	1.64	1.67	1.67	1.61	1.66	1.67	1.65
Fe	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Ca	0.69	0.69	0.70	0.64	0.68	0.72	0.70	0.62	0.68	0.69	0.68
Na	0.33	0.32	0.32	0.35	0.32	0.32	0.33	0.39	0.34	0.34	0.34
K	0.02	0.01	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.02
Sr	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Or	1.43	1.30	1.49	1.75	1.45	1.36	1.36	2.22	1.57	1.42	1.85
Ab	31.66	31.32	30.87	34.54	31.70	30.04	31.34	37.32	32.57	32.56	32.36
An	66.77	67.35	67.49	63.57	66.72	68.52	67.18	60.26	65.71	65.93	65.61

[1]based on 8 oxygens

Appendix E

E:9 Composition of plagioclase phenocrysts and groundmass (gm) from LW21FVP of Ql1d

Point	lw21_#13e gm	lw21_#14ab gm	lw21_#14a gm	lw21_#14a gm	lw21_#14ab gm	lw21_#14bb gm	lw21_#14b gm	lw21_#14be gm
SiO_2	56.04	52.30	48.22	47.90	48.51	55.29	49.17	49.41
Al_2O_3	25.34	28.86	29.94	29.94	30.20	21.49	29.45	29.14
FeO	0.71	0.86	0.78	0.73	0.67	3.45	0.90	0.88
CaO	7.76	11.89	13.71	13.85	13.79	9.08	13.19	12.53
Na_2O	6.42	4.64	3.66	3.62	3.58	4.85	3.94	4.08
K_2O	1.01	0.39	0.24	0.23	0.24	2.07	0.33	0.37
SrO	0.24	0.35	0.36	0.33	0.34	0.08	0.34	0.36
BaO	0.41	0.12	0.04	0.02	0.10	0.17	0.06	0.11
TOTAL	97.93	99.40	96.95	96.62	97.42	96.49	97.37	96.89
Cations[1]								
Si	2.59	2.40	2.29	2.28	2.29	2.64	2.32	2.34
Al	1.38	1.56	1.67	1.68	1.68	1.21	1.64	1.63
Fe	0.03	0.03	0.03	0.03	0.03	0.14	0.04	0.04
Ca	0.39	0.59	0.70	0.71	0.70	0.47	0.67	0.64
Na	0.58	0.41	0.34	0.33	0.33	0.45	0.36	0.38
K	0.06	0.02	0.02	0.01	0.01	0.13	0.02	0.02
Sr	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01
Ba	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Or	5.80	2.23	1.39	1.32	1.37	12.10	1.90	2.18
Ab	56.03	40.40	32.10	31.68	31.44	43.06	34.41	36.19
An	37.44	57.17	66.44	66.96	67.02	44.53	63.60	61.44

[1]based on 8 oxygens

Appendix E

E:10 Composition of plagioclase phenocrysts and groundmass (gm) from LW73FVP of Ql1b

Point	LW73ph1b	LW73ph1	LW73ph1	LW73ph1	LW73ph1	LW73ph1	LW73ph1e	LW73ph2b	LW73ph2	LW73ph2	LW73ph2	LW73ph2e
SiO_2	50.65	50.53	51.10	50.42	50.50	50.30	51.28	51.06	51.15	51.24	51.49	52.13
Al_2O_3	30.55	30.68	30.39	30.98	30.48	30.07	29.90	30.43	30.91	30.35	30.70	29.70
FeO	0.69	0.61	0.71	0.62	0.64	0.59	0.81	0.76	0.68	0.67	0.69	0.87
CaO	13.64	13.70	13.55	13.71	13.80	13.32	13.13	13.76	13.72	13.51	13.55	12.80
Na_2O	3.43	3.50	3.59	3.38	3.43	3.55	3.77	3.51	3.52	3.50	3.58	3.86
K_2O	0.30	0.25	0.32	0.23	0.23	0.28	0.35	0.26	0.21	0.22	0.24	0.35
SrO	0.34	0.21	0.22	0.35	0.33	0.35	0.42	0.24	0.29	0.33	0.34	0.28
BaO	0.07	0.09	0.08	0.05	0.08	0.12	0.13	0.12	0.07	0.07	0.06	0.10
TOTAL	99.67	99.57	99.97	99.75	99.48	98.57	99.78	100.13	100.54	99.89	100.64	100.09
Cations[1]												
Si	2.33	2.32	2.34	2.31	2.32	2.33	2.35	2.33	2.33	2.34	2.34	2.38
Al	1.65	1.66	1.64	1.67	1.65	1.65	1.62	1.64	1.66	1.64	1.64	1.60
Fe	0.03	0.02	0.03	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03
Ca	0.67	0.67	0.66	0.67	0.68	0.66	0.65	0.67	0.67	0.66	0.66	0.63
Na	0.31	0.31	0.32	0.30	0.31	0.32	0.34	0.31	0.31	0.31	0.32	0.34
K	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.02
Sr	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Or	1.76	1.48	1.87	1.36	1.34	1.63	2.05	1.50	1.25	1.30	1.41	2.07
Ab	30.71	31.07	31.76	30.40	30.55	31.91	33.42	31.04	31.29	31.45	31.85	34.49
An	67.40	67.28	66.22	68.15	67.97	66.24	64.31	67.24	67.34	67.13	66.63	63.25

[1]based on 8 oxygens

Appendix E

E:10 Composition of plagioclase phenocrysts and groundmass (gm) from LW73FVP of Ql1b

Point	LW73ph4b	LW73ph4	LW73ph4	LW73ph4	LW73ph4	LW73ph4	LW73ph4e	LW73ph1_gm1 gm	LW73ph1_gm1 gm	LW73ph1_gm2 gm
SiO_2	49.46	50.34	49.27	48.85	49.51	49.92	49.83	53.54	52.47	54.47
Al_2O_3	31.00	30.99	31.06	30.68	30.88	30.80	30.50	28.70	29.73	27.60
FeO	0.72	0.68	0.70	0.69	0.67	0.71	0.66	0.90	1.00	0.86
CaO	13.57	13.88	14.04	13.69	13.74	13.57	13.54	11.64	12.38	10.18
Na_2O	3.43	3.46	3.34	3.29	3.46	3.53	3.47	4.53	4.06	4.97
K_2O	0.27	0.26	0.19	0.20	0.21	0.26	0.27	0.49	0.45	1.05
SrO	0.26	0.27	0.30	0.28	0.32	0.26	0.32	0.22	0.28	0.22
BaO	0.06	0.00	0.03	0.00	0.05	0.05	0.06	0.08	0.10	0.31
TOTAL	98.77	99.87	98.93	97.67	98.83	99.09	98.64	100.10	100.47	99.67
Cations[1]										
Si	2.29	2.31	2.28	2.29	2.30	2.31	2.31	2.44	2.39	2.49
Al	1.69	1.67	1.70	1.70	1.69	1.68	1.67	1.54	1.59	1.49
Fe	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03
Ca	0.67	0.68	0.70	0.69	0.68	0.67	0.67	0.57	0.60	0.50
Na	0.31	0.31	0.30	0.30	0.31	0.32	0.31	0.40	0.36	0.44
K	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.06
Sr	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Or	1.58	1.48	1.12	1.22	1.22	1.50	1.61	2.84	2.66	6.10
Ab	30.86	30.63	29.72	29.91	30.87	31.50	31.15	40.07	36.16	43.79
An	67.45	67.89	69.12	68.86	67.82	66.91	67.14	56.95	61.00	49.55

[1]based on 8 oxygens

Appendix E

E:10 Composition of plagioclase phenocrysts and groundmass (gm) from LW73FVP of Ql1b

Point	LW73ph1_gm2 gm	LW73ph1_gm3 gm	LW73ph1_gm3 gm	LW73ph1_gm3 gm	LW73ph2_gm1 gm	LW73ph2_gm1 gm	LW73ph2_gm1 gm	LW73ph2_gm2 gm
SiO_2	51.33	52.91	56.59	59.98	51.37	51.07	51.74	51.80
Al_2O_3	29.89	28.99	25.52	22.48	29.57	30.61	30.02	30.18
FeO	0.85	0.91	0.65	0.63	0.90	0.81	0.99	0.82
CaO	12.87	12.06	8.07	4.62	12.72	13.24	12.75	13.24
Na_2O	3.84	4.28	6.10	6.52	3.89	3.60	3.97	3.60
K_2O	0.36	0.44	0.98	2.80	0.38	0.34	0.37	0.35
SrO	0.36	0.19	0.26	0.16	0.33	0.34	0.24	0.30
BaO	0.07	0.08	0.28	1.01	0.09	0.02	0.13	0.04
TOTAL	99.56	99.87	98.44	98.20	99.26	100.04	100.21	100.33
Cations[1]								
Si	2.36	2.41	2.60	2.76	2.37	2.33	2.36	2.36
Al	1.62	1.56	1.38	1.22	1.61	1.65	1.61	1.62
Fe	0.03	0.04	0.03	0.02	0.04	0.03	0.04	0.03
Ca	0.63	0.59	0.40	0.23	0.63	0.65	0.62	0.65
Na	0.34	0.38	0.54	0.58	0.35	0.32	0.35	0.32
K	0.02	0.03	0.06	0.17	0.02	0.02	0.02	0.02
Sr	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01
Ba	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00
Or	2.13	2.60	5.72	16.59	2.26	2.01	2.17	2.04
Ab	34.25	38.06	54.15	58.63	34.76	32.31	35.15	32.30
An	63.50	59.20	39.62	22.94	62.82	65.65	62.44	65.58

[1]based on 8 oxygens

Appendix E

E:10 Composition of plagioclase phenocrysts and groundmass (gm) from LW73FVP of Ql1b

Point	LW73ph2_gm2 gm	LW73ph2_gm2 gm	LW73ph4_gm1 gm	LW73ph4_gm1 gm	LW73ph4_gm1 gm	LW73ph4_gm2 gm	LW73ph4_gm2 gm	LW73ph4_gm3 gm
SiO_2	51.49	51.87	51.83	52.32	53.32	52.03	51.08	51.89
Al_2O_3	30.05	29.50	30.01	29.45	29.01	29.21	29.94	29.14
FeO	0.79	0.93	0.95	0.81	0.88	0.93	1.00	0.91
CaO	13.13	12.19	12.76	12.44	11.88	11.96	12.71	12.06
Na_2O	3.73	4.19	3.97	4.19	4.57	4.38	3.97	4.24
K_2O	0.36	0.44	0.38	0.43	0.48	0.47	0.41	0.46
SrO	0.43	0.32	0.40	0.32	0.25	0.21	0.29	0.22
BaO	0.13	0.09	0.10	0.07	0.04	0.11	0.05	0.06
TOTAL	100.11	99.52	100.39	100.01	100.43	99.29	99.46	98.98
Cations[1]								
Si	2.35	2.38	2.36	2.39	2.42	2.39	2.35	2.39
Al	1.62	1.60	1.61	1.58	1.55	1.58	1.62	1.58
Fe	0.03	0.04	0.04	0.03	0.03	0.04	0.04	0.04
Ca	0.64	0.60	0.62	0.61	0.58	0.59	0.63	0.60
Na	0.33	0.37	0.35	0.37	0.40	0.39	0.35	0.38
K	0.02	0.03	0.02	0.03	0.03	0.03	0.02	0.03
Sr	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Or	2.09	2.57	2.21	2.47	2.72	2.74	2.40	2.70
Ab	33.14	37.33	35.15	36.87	39.91	38.66	35.21	37.78
An	64.53	59.94	62.46	60.54	57.30	58.39	62.30	59.41

[1]based on 8 oxygens

Appendix E

E:10 Composition of plagioclase phenocrysts and groundmass (gm) from LW73FVP of Ql1b

Point	LW73ph4_gm3
	gm
SiO_2	50.56
Al_2O_3	29.60
FeO	0.90
CaO	12.67
Na_2O	3.88
K_2O	0.40
SrO	0.35
BaO	0.14
TOTAL	98.50
Cations[1]	
Si	2.35
Al	1.62
Fe	0.04
Ca	0.63
Na	0.35
K	0.02
Sr	0.01
Ba	0.00
Or	2.35
Ab	34.71
An	62.68

[1]based on 8 oxygens

Appendix E

E:11 Composition of groundmass plagioclase from LW40FVP of Ql2a

Point	lw40#6_1_1	lw40#6_2_1	lw40#6_2_2	lw40#6_2_3	lw40#3_1_1	lw40#3_1_2	lw40#3_2_1
SiO_2	53.89	51.87	50.65	51.24	51.36	52.40	51.76
Al_2O_3	28.06	29.97	30.71	30.27	30.20	29.22	29.92
FeO	0.95	0.92	0.82	1.00	1.05	1.01	0.96
CaO	10.88	12.60	13.76	13.21	13.18	11.92	12.50
Na_2O	4.91	4.00	3.52	3.67	3.78	4.40	4.21
K_2O	0.60	0.39	0.29	0.32	0.34	0.51	0.43
SrO	0.25	0.38	0.31	0.31	0.32	0.27	0.27
TOTAL	99.64	100.27	100.08	100.08	100.30	99.88	100.14
Cations[1]							
Si	2.46	2.37	2.32	2.34	2.35	2.40	2.36
Al	1.51	1.61	1.66	1.63	1.63	1.58	1.61
Fe	0.04	0.04	0.03	0.04	0.04	0.04	0.04
Ca	0.53	0.62	0.68	0.65	0.65	0.58	0.61
Na	0.44	0.35	0.31	0.33	0.33	0.39	0.37
K	0.04	0.02	0.02	0.02	0.02	0.03	0.03
Sr	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Or	3.51	2.27	1.71	1.85	1.97	2.97	2.50
Ab	43.27	35.55	31.10	32.77	33.42	38.76	36.84
An	53.03	61.92	67.13	65.24	64.46	57.99	60.49

[1]based on 8 oxygens

Appendix E

E:12 Composition of groundmass plagioclase from LW61FVP of Ql3

Point	lw61fvp_#1_f1	lw61fvp_#1_f2	lw61fvp_#1_f3	lw61fvp_#1_f4
SiO_2	50.74	50.82	49.82	49.77
Al_2O_3	30.43	29.59	30.83	30.88
FeO	1.02	0.95	0.84	0.81
CaO	13.05	12.43	13.62	13.36
Na_2O	3.67	3.97	3.34	3.55
K_2O	0.37	0.40	0.27	0.30
SrO	0.30	0.29	0.25	0.28
TOTAL	99.57	98.45	98.97	98.94
Cations[1]				
Si	2.33	2.36	2.30	2.30
Al	1.65	1.62	1.68	1.68
Fe	0.04	0.04	0.03	0.03
Ca	0.64	0.62	0.68	0.66
Na	0.33	0.36	0.30	0.32
K	0.02	0.02	0.02	0.02
Sr	0.01	0.01	0.01	0.01
Or	2.18	2.38	1.60	1.79
Ab	33.00	35.75	30.21	31.88
An	64.82	61.87	68.19	66.33

[1]based on 8 oxygens

Appendix E

E:13 Composition of groundmass pyroxene from LW21FVP of Ql1d

Point	lw21_#13_b	lw21_#13_c	lw21_#14_c
SiO_2	48.24	48.90	50.10
TiO_2	2.29	2.05	1.56
Al_2O_3	4.22	3.56	2.61
Fe_2O_3	7.32	8.09	8.16
FeO	3.16	2.86	1.94
MnO	0.22	0.27	0.31
Cr_2O_3	0.02	0.03	0.00
Na_2O	0.41	0.44	0.34
MgO	13.27	13.64	14.26
CaO	20.79	20.00	20.19
TOTAL	99.92	99.83	99.47
Cations[1]			
Si	1.81	1.84	1.88
Ti	0.07	0.06	0.04
Al	0.19	0.16	0.12
Fe^{3+}	0.09	0.08	0.06
Fe^{2+}	0.23	0.25	0.26
Mn	0.01	0.01	0.01
Cr	0.00	0.00	0.00
Na	0.03	0.03	0.03
Mg	0.74	0.76	0.80
Ca	0.84	0.81	0.81
Wo	46.06	43.95	43.28
En	40.91	41.71	42.54
Fs	13.03	14.35	14.18

[1]based on 6 oxygens

Appendix E

E:14 Composition of groundmass pyroxene from LW40FVP of Ql2a

Point	lw40_#3_a1	lw40_#3_a2	lw40_#3_b1	lw40_#3_b2	lw40_#3_c1	lw40_#3_c2
SiO_2	47.73	46.45	46.88	46.68	46.15	46.88
TiO_2	3.03	3.30	3.54	3.50	3.62	3.43
Al_2O_3	4.16	4.03	4.42	4.13	4.19	4.76
Fe_2O_3	11.83	8.69	10.15	9.30	9.89	10.46
FeO	0.00	3.13	1.72	2.77	2.71	1.55
MnO	0.31	0.23	0.26	0.28	0.22	0.21
Cr_2O_3	0.02	0.01	0.00	0.02	0.01	0.01
Na_2O	0.62	0.52	0.48	0.51	0.55	0.64
MgO	10.92	11.95	11.69	11.72	11.40	11.27
CaO	19.18	20.20	20.12	20.41	19.88	19.84
TOTAL	97.80	98.51	99.26	99.31	98.62	99.05
Cations[1]						
Si	1.85	1.79	1.79	1.79	1.78	1.80
Ti	0.09	0.10	0.10	0.10	0.11	0.10
Al	0.19	0.18	0.20	0.19	0.19	0.22
Fe^{3+}	0.00	0.09	0.05	0.08	0.08	0.05
Fe^{2+}	0.38	0.28	0.33	0.30	0.32	0.34
Mn	0.01	0.01	0.01	0.01	0.01	0.01
Cr	0.00	0.00	0.00	0.00	0.00	0.00
Na	0.05	0.04	0.04	0.04	0.04	0.05
Mg	0.63	0.69	0.67	0.67	0.66	0.64
Ca	0.80	0.83	0.82	0.84	0.82	0.81
Wo	43.75	46.13	45.20	46.18	45.57	45.24
En	34.63	37.97	36.53	36.89	36.34	35.76
Fs	21.62	15.89	18.27	16.93	18.10	19.00

[1]based on 6 oxygens

Appendix E

E:15 Composition of magnetite inclusions in olivine and groundmass (gm) magnetite from LW21FVP of Ql1d

Point	lw21fvp_2m	lw21fvp_2m	lw21fvp_2ma	lw21fvp_2ma	lw21fvp_4m	lw21fvp_4m	lw21fvp_4m	lw21fvp_4ma	lw21fvp_4ma
SiO_2	0.11	0.10	0.15	0.09	0.11	0.10	0.08	0.08	0.07
TiO_2	10.14	8.81	13.38	11.00	14.46	16.79	18.21	16.75	16.07
Al_2O_3	8.49	9.10	5.56	8.15	4.20	3.39	2.67	3.52	4.19
Cr_2O_3	4.16	7.21	3.94	4.60	4.44	2.20	2.88	3.42	3.41
FeO	32.93	31.22	37.19	35.02	39.36	41.42	42.78	41.31	41.05
Fe_2O_3	35.66	35.18	32.36	34.16	31.80	30.58	28.58	29.78	30.28
MnO	0.23	0.31	0.38	0.34	0.42	0.55	0.59	0.49	0.42
MgO	5.08	5.59	3.83	4.32	3.13	3.03	3.07	3.26	3.14
ZnO	0.16	0.11	0.04	0.17	0.02	0.09	0.11	0.05	0.09
TOTAL	96.96	97.62	96.81	97.86	97.94	98.15	98.97	98.66	98.73
Cations[1]									
Si	0.03	0.03	0.04	0.03	0.03	0.03	0.02	0.02	0.02
Ti	2.20	1.88	2.97	2.38	3.21	3.73	4.03	3.70	3.54
Al	2.88	3.05	1.93	2.76	1.46	1.18	0.93	1.22	1.44
Cr	0.95	1.62	0.92	1.05	1.04	0.51	0.67	0.79	0.79
Fe^{2+}	7.73	7.53	7.18	7.39	7.06	6.80	6.32	6.57	6.67
Fe^{3+}	7.93	7.42	9.17	8.42	9.71	10.24	10.52	10.13	10.04
Mn	0.06	0.08	0.09	0.08	0.11	0.14	0.15	0.12	0.11
Mg	2.18	2.37	1.68	1.85	1.38	1.34	1.35	1.43	1.37
Zn	0.03	0.02	0.01	0.04	0.01	0.02	0.03	0.01	0.02

[1]based on 32 oxygens

Appendix E

E:15 Composition of magnetite inclusions in olivine and groundmass (gm) magnetite from LW21FVP of Ql1d

Point	lw21fvp_5m	lw21fvp_5m	lw21fvp_5m	lw21fvp_5ma	lw21fvp_5ma	lw21fvp_5mb	lw21fvp_5mb	lw21fvp_5mc gm	lw21fvp_5mc gm
SiO_2	0.10	0.08	0.08	0.12	0.10	0.09	0.11	0.14	0.07
TiO_2	7.70	7.53	7.51	10.78	10.67	12.75	14.02	14.51	12.52
Al_2O_3	13.15	12.96	12.33	7.66	7.60	6.20	5.45	5.40	6.26
Cr_2O_3	8.68	9.21	8.43	1.95	2.41	3.48	2.89	0.38	0.37
FeO	30.60	30.32	30.09	34.06	34.00	36.88	38.57	39.83	38.11
Fe_2O_3	32.37	32.59	33.27	39.01	39.33	34.58	34.08	35.01	38.52
MnO	0.28	0.21	0.26	0.27	0.28	0.38	0.46	0.40	0.32
MgO	6.12	6.26	6.06	5.01	5.11	4.07	3.77	3.14	3.37
ZnO	0.08	0.10	0.07	0.12	0.17	0.09	0.08	0.08	0.14
TOTAL	99.06	99.25	98.10	98.98	99.66	98.51	99.42	98.89	99.66
Cations[1]									
Si	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.02
Ti	1.59	1.55	1.57	2.31	2.27	2.77	3.04	3.17	2.71
Al	4.24	4.18	4.03	2.56	2.53	2.11	1.85	1.85	2.12
Cr	1.88	1.99	1.85	0.44	0.54	0.80	0.66	0.09	0.08
Fe^{2+}	6.67	6.71	6.95	8.34	8.36	7.52	7.38	7.66	8.34
Fe^{3+}	7.01	6.93	6.98	8.10	8.03	8.91	9.29	9.69	9.17
Mn	0.06	0.05	0.06	0.06	0.07	0.09	0.11	0.10	0.08
Mg	2.50	2.55	2.51	2.12	2.15	1.75	1.62	1.36	1.44
Zn	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.03

[1]based on 32 oxygens

Appendix E

E:15 Composition of magnetite inclusions in olivine and groundmass (gm) magnetite from LW21FVP of Ql1d

Point	lw21fvp_5mc gm	lw21fvp_5mc gm	lw21fvp_13m gm	lw21fvp_13m gm	lw21_#13_a gm	lw21_#13_a gm	lw21_#13_a gm	lw21fvp_14m gm	lw21_#14_a gm
SiO_2	0.10	0.10	0.12	0.13	0.11	0.12	0.12	0.11	0.13
TiO_2	12.20	12.60	21.61	21.72	20.43	19.87	20.70	18.39	18.05
Al_2O_3	6.20	6.11	1.95	1.61	1.79	1.71	1.93	2.65	1.43
Cr_2O_3	0.37	0.33	0.07	0.09	0.02	0.05	0.09	0.04	0.05
FeO	37.55	38.18	46.09	45.97	44.91	44.44	45.10	42.29	44.00
Fe_2O_3	39.22	38.43	22.84	23.00	27.25	27.74	26.10	30.28	31.38
MnO	0.39	0.32	0.43	0.62	0.60	0.54	0.62	0.54	0.49
MgO	3.48	3.31	2.26	2.24	2.67	2.49	2.61	3.22	1.74
ZnO	0.07	0.00	0.12	0.08	0.04	0.13	0.04	0.12	0.16
TOTAL	99.58	99.37	95.49	95.45	97.82	97.09	97.31	97.63	97.43
Cations[1]									
Si	0.03	0.03	0.04	0.04	0.03	0.04	0.04	0.03	0.04
Ti	2.64	2.74	4.98	5.02	4.60	4.51	4.68	4.12	4.12
Al	2.10	2.08	0.71	0.58	0.63	0.61	0.68	0.93	0.51
Cr	0.08	0.08	0.02	0.02	0.01	0.01	0.02	0.01	0.01
Fe^{2+}	8.49	8.35	5.27	5.32	6.13	6.30	5.90	6.78	7.17
Fe^{3+}	9.04	9.22	11.81	11.81	11.23	11.23	11.33	10.53	11.18
Mn	0.09	0.08	0.11	0.16	0.15	0.14	0.16	0.14	0.13
Mg	1.49	1.42	1.03	1.02	1.19	1.12	1.17	1.43	0.79
Zn	0.02	0.00	0.03	0.02	0.01	0.03	0.01	0.03	0.04

[1]based on 32 oxygens

Appendix E

E:15 Composition of magnetite inclusions in olivine and groundmass (gm) magnetite from LW21FVP of Ql1d

Point	lw21_#14_a	lw21_#14_b	lw21_#14_b	lw21_#14_b	lw21_#14_b
	gm	gm	gm	gm	gm
SiO_2	0.15	0.15	0.15	0.12	0.11
TiO_2	20.64	20.12	20.16	19.45	19.34
Al_2O_3	1.69	1.54	1.62	1.76	1.68
Cr_2O_3	0.02	0.12	0.12	0.14	0.24
FeO	44.73	44.51	44.82	43.72	43.65
Fe_2O_3	26.07	27.43	27.88	28.96	29.37
MnO	0.55	0.63	0.59	0.67	0.57
MgO	2.67	2.54	2.57	2.76	2.84
ZnO	0.17	0.09	0.15	0.19	0.11
TOTAL	96.69	97.14	98.07	97.77	97.90
Cations[1]					
Si	0.05	0.05	0.04	0.04	0.03
Ti	4.70	4.57	4.53	4.38	4.35
Al	0.60	0.55	0.57	0.62	0.59
Cr	0.01	0.03	0.03	0.03	0.06
Fe^{2+}	5.94	6.23	6.27	6.53	6.61
Fe^{3+}	11.32	11.24	11.21	10.95	10.92
Mn	0.14	0.16	0.15	0.17	0.14
Mg	1.21	1.14	1.15	1.23	1.27
Zn	0.04	0.02	0.03	0.04	0.02

[1]based on 32 oxygens

Appendix E

E:16 Composition of magnetite inclusions in olivine and groundmass (gm) magnetite from LW40FVP of Ql2a

Point	lw40#1_a	lw40#1_a	lw40#1_a	lw40#1_b	lw40#1_b	lw40#1_b	lw40#1_c gm	lw40#1_c gm	lw40#1_c gm	lw40#6_a gm	lw40#6_a gm
SiO_2	0.10	0.09	0.11	0.10	0.71	0.12	0.13	0.10	0.14	0.11	0.10
TiO_2	15.58	15.08	13.85	7.28	7.34	7.21	18.23	18.10	17.89	17.12	16.18
Al_2O_3	3.03	3.24	3.74	13.21	12.87	12.73	1.97	1.87	1.72	2.06	2.49
Cr_2O_3	1.67	2.00	3.84	9.37	9.35	8.85	0.32	0.21	0.17	0.41	0.68
FeO	40.62	40.02	38.60	29.09	28.61	28.83	44.24	44.11	43.66	42.56	41.57
Fe_2O_3	34.76	35.17	35.26	32.01	32.19	32.71	30.34	30.39	31.05	33.07	34.48
MnO	0.43	0.39	0.49	0.29	0.23	0.24	0.51	0.51	0.51	0.53	0.51
MgO	3.11	3.24	3.44	6.66	6.92	6.60	1.81	1.70	1.83	2.37	2.58
ZnO	0.10	0.02	0.05	0.12	0.15	0.16	0.00	0.12	0.08	0.20	0.10
TOTAL	99.39	99.23	99.37	98.12	98.37	97.44	97.56	97.10	97.04	98.42	98.68
Cations[1]											
Si	0.03	0.03	0.03	0.03	0.19	0.03	0.04	0.03	0.04	0.03	0.03
Ti	3.43	3.32	3.03	1.51	1.51	1.51	4.14	4.14	4.09	3.85	3.61
Al	1.05	1.12	1.28	4.28	4.14	4.17	0.70	0.67	0.62	0.72	0.87
Cr	0.39	0.46	0.88	2.04	2.02	1.94	0.08	0.05	0.04	0.10	0.16
Fe^{2+}	7.66	7.75	7.73	6.63	6.61	6.83	6.90	6.96	7.11	7.43	7.70
Fe^{3+}	9.95	9.80	9.40	6.69	6.53	6.69	11.18	11.22	11.11	10.63	10.32
Mn	0.11	0.10	0.12	0.07	0.05	0.06	0.13	0.13	0.13	0.13	0.13
Mg	1.36	1.41	1.49	2.73	2.82	2.73	0.81	0.77	0.83	1.05	1.14
Zn	0.02	0.00	0.01	0.02	0.03	0.03	0.00	0.03	0.02	0.04	0.02

[1]based on 32 oxygens

Appendix E

E:16 Composition of magnetite inclusions in olivine and groundmass (gm) magnetite from LW40FVP of Ql2a

Point	lw40#6_a gm	lw40#6_b gm	lw40#6_b gm	lw40#6_b gm	lw40#6_c	lw40#6_c	lw40#6_c	lw40fvp#3_m1 gm	lw40fvp#3_m2 gm
SiO_2	0.13	0.11	0.12	0.11	0.10	0.13	0.11	0.11	0.11
TiO_2	16.49	17.13	16.70	16.79	14.32	15.45	16.81	17.27	21.66
Al_2O_3	2.18	1.94	2.35	2.08	3.46	2.80	1.89	2.45	1.50
Cr_2O_3	0.58	0.47	0.59	0.46	3.10	1.91	1.38	0.41	0.21
FeO	41.91	42.67	42.44	42.26	39.06	40.05	41.58	42.79	47.87
Fe_2O_3	34.51	34.11	34.88	34.50	35.09	34.55	33.27	32.59	22.73
MnO	0.51	0.47	0.42	0.52	0.42	0.45	0.50	0.46	0.46
MgO	2.57	2.58	2.69	2.60	3.34	3.19	2.86	2.45	1.13
ZnO	0.05	0.10	0.27	0.20	0.09	0.17	0.05	0.19	0.11
TOTAL	98.91	99.58	100.45	99.51	98.98	98.70	98.43	98.71	95.78
Cations[1]									
Si	0.04	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.04
Ti	3.68	3.80	3.67	3.73	3.16	3.43	3.76	3.86	5.03
Al	0.76	0.68	0.81	0.72	1.20	0.97	0.66	0.86	0.55
Cr	0.14	0.11	0.14	0.11	0.72	0.44	0.32	0.10	0.05
Fe^{2+}	7.70	7.57	7.66	7.66	7.74	7.67	7.45	7.28	5.29
Fe^{3+}	10.40	10.53	10.36	10.43	9.57	9.88	10.35	10.63	12.37
Mn	0.13	0.12	0.11	0.13	0.10	0.11	0.13	0.12	0.12
Mg	1.13	1.13	1.17	1.14	1.46	1.40	1.27	1.09	0.52
Zn	0.01	0.02	0.06	0.04	0.02	0.04	0.01	0.04	0.03

[1]based on 32 oxygens

Appendix E

E:16 Composition of magnetite inclusions in olivine and groundmass (gm) magnetite from LW40FVP of Ql2a

Point	lw40fvp#3_m3
	gm
SiO_2	0.11
TiO_2	20.53
Al_2O_3	1.62
Cr_2O_3	0.32
FeO	46.94
Fe_2O_3	25.31
MnO	0.48
MgO	1.22
ZnO	0.05
TOTAL	96.58
Cations[1]	
Si	0.03
Ti	4.73
Al	0.59
Cr	0.08
Fe^{2+}	5.84
Fe^{3+}	12.03
Mn	0.12
Mg	0.56
Zn	0.01

[1]based on 32 oxygens

Appendix E

E:17 Composition of magnetite inclusios in olivine from LW135FVP of Qs2fs

Point	lw135_1_mtl	lw135_1_mt2	lw135_3_mtl	lw135_3_mt2	lw135_3_mt3	lw135_3_mt4	lw135_3_mt5	lw135_4_mtl
SiO_2	0.09	0.10	0.10	0.09	0.09	0.08	0.12	0.09
TiO_2	9.44	9.11	9.96	9.58	9.45	9.22	10.03	8.79
Al_2O_3	6.64	7.45	7.47	7.70	7.57	8.07	7.31	8.40
Cr_2O_3	3.96	4.46	3.66	4.25	4.03	5.42	4.69	6.06
FeO	41.24	40.65	39.28	39.45	39.69	38.62	38.18	38.15
Fe_2O_3	33.05	32.58	33.67	33.31	32.03	32.29	33.66	31.43
MnO	0.25	0.22	0.28	0.28	0.17	0.23	0.31	0.29
MgO	4.92	5.18	4.84	4.95	5.54	5.43	4.83	5.63
TOTAL	99.59	99.75	99.25	99.62	98.56	99.35	99.12	98.85
Cations[1]								
Si	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03
Ti	2.02	1.93	2.13	2.04	2.02	1.95	2.15	1.87
Al	2.23	2.48	2.50	2.56	2.54	2.68	2.45	2.79
Cr	0.89	1.00	0.82	0.95	0.91	1.21	1.06	1.35
Fe^{2+}	8.82	8.63	8.40	8.39	8.49	8.19	8.17	8.10
Fe^{3+}	7.86	7.69	8.00	7.87	7.62	7.61	8.01	7.42
Mn	0.06	0.05	0.07	0.07	0.04	0.06	0.07	0.07
Mg	2.08	2.18	2.05	2.09	2.35	2.28	2.05	2.37

[1]based on 32 oxygens

Appendix E

E:17 Composition of magnetite inclusios in olivine from LW135FVP of Qs2fs

Point	lw135_4_mt2	lw135_4_mt3	lw135_4_mt4	lw135_5_mt1	lw135_5_mt2	lw135_5_mt3	lw135_5_mt4
SiO_2	0.09	0.16	0.11	0.10	0.09	0.10	0.10
TiO_2	8.45	9.02	9.75	10.77	7.38	9.06	8.80
Al_2O_3	8.91	7.96	7.06	6.68	10.28	7.46	8.24
Cr_2O_3	6.93	7.08	2.97	1.02	8.68	5.51	6.03
FeO	37.76	36.57	40.95	41.19	36.40	38.86	38.07
Fe_2O_3	31.07	32.33	32.37	33.55	29.69	31.91	31.54
MnO	0.27	0.24	0.23	0.24	0.21	0.22	0.18
MgO	5.84	5.09	5.46	5.22	6.23	5.33	5.54
TOTAL	99.32	98.44	98.90	98.76	98.94	98.44	98.50
Cations[1]							
Si	0.02	0.05	0.03	0.03	0.02	0.03	0.03
Ti	1.78	1.93	2.09	2.32	1.54	1.94	1.88
Al	2.94	2.67	2.37	2.25	3.37	2.51	2.75
Cr	1.53	1.59	0.67	0.23	1.91	1.24	1.35
Fe^{2+}	7.95	7.83	8.76	8.86	7.62	8.34	8.12
Fe^{3+}	7.27	7.69	7.70	8.02	6.90	7.61	7.48
Mn	0.06	0.06	0.05	0.06	0.05	0.05	0.04
Mg	2.43	2.16	2.32	2.22	2.58	2.27	2.34

[1]based on 32 oxygens

Appendix E

E:18 Composition of magnetite inclusions in olivine and groundmass (gm) magnetite from LW61FVP of Ql3

Point	lw61fvp_2_m1	lw61fvp_2_m2	lw61fvp_2_m3	lw61fvp_2_m4	lw61fvp_4_m1	lw61fvp_4_m2	lw61fvp_4_m3 gm	lw61fvp_4_m4
SiO_2	0.09	0.11	0.08	0.08	0.12	0.12	0.07	0.12
TiO_2	15.39	15.16	9.15	8.24	14.97	14.87	13.73	15.86
Al_2O_3	3.31	3.67	9.03	9.73	3.67	4.20	4.67	3.33
Cr_2O_3	1.48	1.92	9.09	7.41	2.16	0.61	2.81	0.18
FeO	40.08	38.79	32.04	29.89	38.02	37.78	36.89	40.34
Fe_2O_3	34.75	35.10	34.29	37.19	35.43	36.05	35.91	35.28
MnO	0.46	0.37	0.33	0.26	0.41	0.38	0.40	0.46
MgO	3.26	4.14	5.71	6.59	4.51	4.51	4.58	3.38
ZnO	0.05	0.21	0.01	0.04	0.17	0.00	0.04	0.17
TOTAL	98.86	99.48	99.74	99.42	99.45	98.53	99.09	99.11
Cations[1]								
Si	0.03	0.03	0.02	0.02	0.04	0.03	0.02	0.04
Ti	3.40	3.30	1.92	1.72	3.25	3.25	2.98	3.49
Al	1.15	1.25	2.96	3.17	1.25	1.44	1.59	1.15
Cr	0.34	0.44	2.00	1.62	0.49	0.14	0.64	0.04
Fe^{2+}	9.84	9.40	7.46	6.92	9.18	9.18	8.90	9.88
Fe^{3+}	7.68	7.65	7.18	7.75	7.70	7.88	7.79	7.77
Mn	0.11	0.09	0.08	0.06	0.10	0.10	0.10	0.11
Mg	1.43	1.79	2.37	2.72	1.94	1.96	1.97	1.47
Zn	0.01	0.04	0.00	0.01	0.04	0.00	0.01	0.04

[1]based on 32 oxygens

• U.S. GOVERNMENT PRINTING OFFICE 1996 - 774 - 028 /27010

Los Alamos
NATIONAL LABORATORY
Los Alamos, New Mexico 87545

This report has been reproduced directly from the best available copy.

It is available to DOE and DOE contractors from the Office of Scientific and Technical Information,
P.O. Box 62,
Oak Ridge, TN 37831.
Prices are available from
(615) 576-8401.

It is available to the public from the
National Technical Information Service,
US Department of Commerce,
5285 Port Royal Rd.
Springfield, VA 22161.