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Mining District File Summary Sheet

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|---|---|
| DISTRICT | Rosebud |
| DIST_NO | 4010 |
| COUNTY<br>If different from written on document | Pershing |
| TITLE<br>If not obvious | Rosebud whole-rock data interpretation and rock names, Jan. '99 |
| AUTHOR | Vance R; Mitchell P; Langstaff G |
| DATE OF DOC(S) | 1998 - 1999 |
| MULTI_DIST Y / N?<br>Additional Dist_Nos: | |
| QUAD_NAME | Sulphur 7½' |
| P_M_C_NAME<br>(mine, claim & company names) | Rosebud Mine; Newmont Gold Co; Rosebud J.V. North Equinox; Wildrose; Dozer; Dreamland |
| COMMODITY<br>If not obvious | gold; silver |
| NOTES | Whole-rock geochemical data report; geology; correspondence; geochemistry<br><br>49p. |

Keep docs at about 250 pages if no oversized maps attached (for every 1 oversized page (>11x17) with text reduce the amount of pages by ~25)

SS: DP 9/11/08
Initials Date

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SCANNED:
Initials Date

Revised: 1/22/08

Whole-Rock Data Interpretation and Rock Names Jan '99

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**NEWMONT GOLD COMPANY**
**ROSEBUD J.V.**

To: Randy Vance, Peter Mitchell Date: January 8, 1998

From: George Langstaff

Subject: **Interpretation of Rosebud Whole-Rock Geochemical Data**

Summary of Rock Names

None of the samples have convincingly alkaline compositions. Consequently, names such as trachyte and trachydacite are avoided even though samples plot in these fields in TAS.

1. The Dozer is **rhyolite**.
2. Aphyric rocks deep in the Dreamland holes are **rhyolite and alkali-feldspar rhyolite**.
3. LBT, Wildrose, brown flow, Brady Andesite and similar sparsely feldspar-phyric rocks are distinct from the aphyric rocks but generally indistinguishable from each other. They are mostly **rhyolite** but some are **quartz latite**.
4. Lac's Chocolate samples are **rhyolite** and are chemically indistinguishable from LBT, etc.
5. Mafic magma-bearing rocks are **rhyolite**, whether aphyric or with sanidine, plagioclase, and quartz phenocrysts. However, the aphyric rocks are chemically distinct.
6. A vitric-lithic lapilli-ash tuff at Dreamland (RS-424) is **high-Si rhyolite** unless its composition has been substantially modified.
7. There are a number of minor intrusive units which are more mafic and less siliceous than the rocks listed above and include the "gorilla" and Big Chocolate Hill. They are best named **quartz latite**. They are chemically similar to LBT, etc.
8. Intrusions in the "Lantern" area are **rhyolite** chemically distinct from the other rhyolites.
9. Intrusive coarsely porphyritic rocks at Dreamland (RS-444) and White Alps (RS-446) are **high-K rhyolite**.
10. A variety of altered intermediate rocks occur deep in the Lucky Boy (RS-422) and White Alps (RS-446) holes. They are **rhyodacite(?)** (abundant plagioclase, minor biotite, and trace hornblende phenocrysts), **dacite** (abundant plagioclase and lesser hornblende phenocrysts), and **andesite** (abundant hornblende microphenocrysts).
11. The Oscar Andesite is **basaltic andesite**.
12. Basalt with locally coarse plagioclase phenocrysts east of the Kamma Mountains is **basalt**.

Purpose

The whole-rock geochemical data for igneous rocks of the Kamma Mountains is used to address the following questions:

1. What is the chemical composition of the rock sample and, hence, what is its proper name?
2. What is the chemical variability within sampled rock units and what is the proper name for these units?
3. Are there chemical criteria which can be used to distinguish between rock units or between stratigraphic units?
4. Are the various igneous rock units geochemically related and, hence, what is the magmatic history of the Kamma Mountains?
5. What are the chemical changes which accompany various types and degrees of alteration?

Answers to question 5 have been summarized in my memo of 11/12/98. The other questions are considered below. The limitations of the data are considered first, then the effects of alteration, and then the different rock classification schemes used. In Interpretation of Results, the most appropriate names for the rock "units" listed in the tables are discussed along with some of the geochemical similarities and differences. Tentative answers to question 4 are summarized in the Summary.

Data

The observations and conclusions summarized here are based on results for 50 samples analyzed by Bondar-Clegg for Lac Minerals in 1988 and for 44 samples analyzed by Chemex for Newmont Gold in 1998.

These data are listed in 4 tables:

Table 1. Summary of Chemical Data – lists analytical results and parameters screened to determine if samples have been chemically altered to a significant degree,

Table 2. Summary of Rock Names for Rosebud Volcanic Rocks Based on Geochemical Classifications – lists parameters used to name rocks by the total alkali vs. silica diagram (TAS), by the normative quartz – alkali feldspar – plagioclase diagram (QAP), and by the Zr/TiO2 vs. Nb/Y "immobile" element diagram (ZTNY),

Table 3. Summary of Petrogenetic Parameters for Rosebud Volcanic Rocks – lists concentrations and ratios for key elements which are least affected by alteration and which may indicate magmatic affiliation,

Table 4. Sample Locations and Descriptions of Rosebud Volcanic Rocks – lists essentially all the available descriptive and location data for the Lac samples, which is woefully inadequate, and brief descriptions for the Newmont samples.

Almost all the Lac samples are listed on a 1:24,000 sample location map kept in the whole rock folder at the Rosebud mine. The version with the drafted lettering has a few more samples than the map on harder stock with colored circles and triangles.

Hand samples for the Newmont samples are at the Rosebud mine. Thin sections and descriptions of the thin sections are available for some of the Newmont samples. There are no hand samples or thin sections for the Lac whole-rock samples although the sample location map indicates samples for thin sections were collected concurrently with many of the whole-rock samples.

Locations (state plane coordinates for surface samples or drill hole number) and descriptions of the Newmont samples are listed in the file C:\Rosebud\Misc\miscsamp.xls on the Rosebud laptop.

Spreadsheet files used to view and manipulate the whole-rock data have the prefix "wh" and are stored in Rbaoi\geochem\wholerk.

Lac samples which have not been used are listed below:

WR-1, 2, 9, 75: no analytical data.

A05746, A05747, B747: no location or descriptive information.

WR-24, 25, 26, 27, 42, 43: samples from the Placerites area.

WR-68: "anorthosite" in Auld Lang Syne Group from an unknown location.
WR-56, 57, 58, 59, 60, 62, 63, 64, 66: "clasts" in Badger Formation.
WR-32, 46, 54: "Bud Bx" and "breccia or heterolithic pyroclastic" from units mapped as base surges by Brady.
WR-69, 73: "Tdt" from unknown locations and apparently altered with <.01% MgO, <60 ppm Sr, <190 ppm Zr, <5 ppm Y, and <500 ppm Ba.
WR-67: apparently altered "white tuff" in Badger Formation with 10% LOI, 11.5% $Al_2O_3$, 290 ppm Ba, 34 ppm Rb, 115 ppm Zr, and <5 ppm Y.
WR-48: apparently altered "white tuff autobreccia" northeast of Dozer Hill (in the Badger Formation?). with .01% MnO, 480 ppm Ba, and 38 ppm Sr.
WR-22: "vitrophyre" on the west flank of the range east of the Crofoot-Lewis mine with an unusual composition, including 8.4% LOI, 13.6% $Al_2O_3$, 2.25% $K_2O$, 3000 ppm Sr, <5 ppm Zr, and 39 ppm Y.

The samples were digested by borate fusion and analyzed by emission spectroscopy by Bondar-Clegg and by x-ray fluorescence by Chemex. The same major and minor elements were analyzed by both labs but Bondar-Clegg also analyzed FeO by titration after extraction with Hf-$H_2SO_4$-HCl. However, $Fe^{3+}/Fe^{2+}$ ratios were well above normal magmatic values for the Bondar-Clegg samples. Except for WR-6, WR-18, and WR-69, which have ratios of .5, .69, and .64 (the lowest of those analyzed), $Fe^{3+}/Fe^{2+}$ ratios of .15 were assumed for the normative calculations and FeO was converted to $Fe_2O_3$ for various plots and lists and for calculating volatile-free oxide concentrations.

Oxide analyses have detection limits of .01 weight%, except .03 weight% for $K_2O$ by Bondar-Clegg. Bondar-Clegg detection limits are 20 ppm for Ba and 5 ppm for Rb, Sr, Nb, Zr, and Y. Chemex detection limits are 5 ppm for Ba, 3 ppm for Zr, and 2 ppm for Rb, Sr, Nb, and Y.

Bondar-Clegg rounded results for Ba, Rb, Sr, and Zr to the nearest 5 ppm.

Samples analyzed by Chemex were pulverized in a tungsten-carbide mill to avoid Fe and Cr contamination but Bondar-Clegg's sample preparation procedures are not known.

No standards or duplicates were submitted so the accuracy and precision of the data are not known.

In three cases, samples analyzed by Chemex and Bondar-Clegg were collected from the same rock units in approximately the same locations. Results for the two labs are compared in Figure 1. The Bondar-Clegg results are consistently lower for Y and $SiO_2$ and higher for $P_2O_5$ than the Chemex results. Although not visible in Figure 1, $SiO_2$ in felsic rocks is 1.2 wt.%, 2.0 wt.%, or 4.1 wt.% lower in the Bondar-Clegg results that in the Chemex results. These relations appear to be true of the data sets in general, as well. In fact, several samples analyzed by Bondar-Clegg have less than the detection limit of 5 ppm Y (a value of 3 ppm is assumed for calculating ratios). The lower Y and $SiO_2$ of the Bondar-Clegg data make the rocks appear to be more alkaline in the TAS and ZTNY classifications than they do with Chemex-analyzed samples. Thus, units which are rhyolite according to the Chemex data may be trachyte, trachydacite, or trachyandesite according to the Bondar-Clegg data.

Effects of Alteration

Before chemical data can be used to determine appropriate igneous rock names, the chemical effects of alteration must be determined. Comparisons of more and less altered samples from the same rock units indicate the following effets which directly affect the rock name:

1. Na is lost during even weak argillic alteration. Na loss shifts the sample toward less alkaline compositions in TAS (e.g., from trachyte to dacite) and, by decreasing the proportion of plagioclase, to more K-spar-rich compositions in QAP (e.g., dacite to rhyolite to alkali-feldspar rhyolite).
2. The effects of argillic alteration on Ca is obscured by the common occurrence of calcite alteration but Ca is probably depleted (loss of Na suggests destruction of plagioclase). Ca may be added in calcite alteration but simultaneous or successive argillic and calcite alteration could result in unpredicatable changes in Ca. Loss of Ca would result in a more K-spar-rich composition but gain of Ca would result in a more plagioclase-rich composition in QAP. The difference between 9% and 61% normative plagioclase in 450:1550.5 to 450:1512.1 (with higher LOI) may be partly due to Ca gain during calcite alteration. However, weak calcite alteration has a very small effect (<5% normative plagioclase) on the pairs 444:1717.8 vs. 444:1727.4 and 444:1920.4 vs. 444:1935.7, possibly due to compensating losses in Na.
3. K decreases moderately during moderate to strong argillic alteration. K loss shifts the sample to more subalkaline compositions in TAS but samples remain within the rhyolite field for the progressive alteration from 446:1918.3 to 446:1907.2 to 446:1901.8 and from 445:1864.3 to 445:1853.4 to 445:1793.6. In QAP, the loss of K is so much less than that of Na and Ca that compositions nonetheless become more K-spar-rich (e.g., from rhyolite to alkali-feldspar rhyolite).
4. Increases in Si alone due to silicification would cause shifts to less alkaline compositions in TAS (e.g., from trachyte to rhyolite) and to more quartz rich compositions in QAP (e.g., from quartz latite to rhyolite). However, Si also increases during argillic alteration as other elements, such as Na and Ca, are lost. This is evident in TAS for 445:1864.3 to 445:1853.4 to 445:1793.6 and for 446:1918.3 to 446:1907.2 to 446:1901.8. In QAP, the more altered of these samples reach unreasonable normative quartz contents of >40% quartz.

The "immobile" elements used in ZTNY do in fact appear to be immobile. There is evidence for mobility of Ti in some cases (e.g., higher in green clay altered 410:943.5 than in 410:1047.6 and in 444:2046.4 than in 444:2019.0) but such mobility is not consistent and is probably negligible for weak argillic or calcite alteration. Changes in these elements due to weak alteration, except possibly green clay alteration, are probably less than the variability within the unaltered rock unit.

In summary, possible changes in QAP are

- Argillic alteration shifts compositions to more K-spar rich and more quartz rich but wouldn't change the name of most Kamma Mountains volcanics, which plot in the lower left of the very large rhyolite field. However, some andesites and dacites could be shifted to the rhyolite field. Moderate to strong argillic alteration may shift compositions to the alkali-feldspar rhyolite field or to unbelievably high normative quartz within the rhyolite field.

- If Ca is added in calcite alteration, rhyolites and quartz latites could be shifted to the dacite and andesite fields, respectively. Alkali-feldspar rhyolites could be shifted to rhyolite. Ca addition is probably not significant for most samples, eve those with moderate calcite.
- Silicification could shift quartz trachytes and quartz latites to the rhyolite field and andesites to the dacite field but such effects have not been documented.
- Green clay alteration apparently has a negligible effect.

Possible changes in TAS are

- Loss of Na during weak argillic alteration may change names for trachyte, trachydacite, or trachyandesite to subalkaline counterparts if the original composition is near the alkaline-subalkaline boundary.
- Moderate to strong argillic or silicic alteration cause shifts to less alkaline and more Si rich compositions and may change names for alkaline rocks but rhyolites and probably dacites generally remain in their respective fields.
- Calcite or hematite alteration alone have no effect.

Changes in rock names due to the gain or loss of "immobile" elements in ZTNY during alteration have not been documented in the Chemex data but an increase in Ti (i.e., a decrease in $Zr/TiO_2$) could shift comendites to rhyolite, rhyolites to dacites, dacites to andesites, and andesites to basalt.

Identification of Altered Samples

In the absence of adequate descriptions for the Lac samples, chemical criteria for recognizing alteration were developed from the Chemex data for Rosebud samples with observable alteration. The criteria are not infallible and are not appropriate for all types of alteration, e.g., addition of Ca only during calcite alteration or addition of Fe during hematite alteration.

**Si/Al > 5.0** [weight % $SiO_2/Al_2O_3$]: samples with unusually high Si/Al could be silicified or may have lost Al; or they could be high-Si rhyolite like 424:2009.6

**A/CNK >1.2** [molar $Al_2O_3/(CaO + Na_2O + K_2O)$]: this is the aluminosity index used to distinguish between metaluminous and peraluminous rocks; high values suggest loss of Ca, Na, or K but not Al during alteration of feldspars; would decrease if Ca is added during calcite alteration

**Na/Ca < 0.3** [weight % $Na_2O/CaO$]: Na appears to be the most mobile element during even weak argillic alteration; low values indicate loss of Na or possibly addition of Ca during calcite alteration; .3 corresponds to a molar ratio of about .25, which would imply a plagioclase composition of An75 – this is not reasonable for felsic rocks

**Rb/Sr > 2** [weight ppm Rb/Sr]: Sr is commonly low in argillically altered rocks and has probably been lost during alteration of plagioclase; a high value implies argillic alteration but, unlike Na/Ca or A/CNK, is independent of calcite alteration

**LOI > 3.0** [weight %]: even 1% may be due to addition of volatiles but a value that low would eliminate all the samples; samples with >3% LOI generally have moderate calcite or are otherwise visibly altered

**$Na_2O$ < 0.5** [weight %]: the 1-standard deviation range for average rhyolite is 2.33-4.91% so a value this low would be clear evidence of alteration, which might not be detected by other parameters

**CaO < 0.3** [weight%]: the 1-standard deviation range for average rhyolite is .2-2.12% but .3 is probably a reasonable lower limit for other than high-Si rhyolites; much Ca may be fixed by calcite during alteration of plagioclase

**MgO < 0.05** [weight%]: the 1-standard deviation range for average rhyolite is 0-.9% but most Kamma Mountains samples have >.1%; Mg may be lost during bleaching or destruction of mafic silicate minerals; however, Mg seems to increase in green clay alteration

Although the criteria discussed above are useful for identifying the most altered samples, they may miss some weakly altered samples. Igneous petrologists routinely reject analyses with LOI >2 weight %. More detailed criteria could be developed just for the felsic rocks (e.g., maximum CaO < 4.5 weight %) or just for the intermediate and basaltic rocks but are not justifiable without more samples known to be unaltered.

Finally, even altered rocks can provide useful information. Some trace element ratios are apparently unaffected by most alteration. As discussed above, some changes in chemical composition would not change a rock's name. Although calcite alteration alone might change the rock name in QAP, the rock name would not change in TAS. Na loss might be sufficient to change the name in TAS but not in QAP. Consequently, by considering the rock names determined by different classification schemes and all the available petrographic data, one could determine an appropriate, consistent, and understandable rock name.

Notes on the QAP Classification

The classification of volcanic rocks using the Quartz - Alkali-Feldspar –Plagioclase - Feldspathoid (QAPF) diagram was formalized by the IUGS in 1979 (Streckeisen, 1979). As no feldspathoids occur in the Kamma Mountains, only the QAP part of the diagram is relevant. QAP classification is based on the relative proportions of quartz, K-feldspar + albite, and plagioclase (more calcic than albite) identified in the rock. The normative anorthite content of plagioclase is listed in Table 2 so that samples with albitic plagioclase (An<10%) can be correctly identified as alkali-feldspar rhyolite or alkali-feldspar quartz trachyte.

If a rock contains a substantial amount of glass or its constituent minerals cannot be identified due to fine grain size or alteration, the name of the rock cannot be determined directly. The IUGS Subcommission on the Systematics of Igneous Rocks stated that "calculating the stable mineral assemblage of igneous rocks from the chemical analyses so that they can be plotted directly on the QAPF diagram . . . is nevertheless a useful method of obtaining a first approximation of the modal composition of the rock."

For Kamma Mountains samples, CIPW norms have been calculated and converted from weight percents to volume percents to better approximate visually estimated modal mineral contents.

A norm may differ from a mode for several reasons. For the calculations here, a $Fe^{3+}/Fe^{2+}$ ratio of .15 has been assumed. This is the most widely used assumption but is more appropriate for mafic than for felsic rocks. As $Fe^{2+}$ can enter either magnetite or mafic silicates but $Fe^{3+}$ enters only oxides (except, rarely, the sodic pyroxene, acmite), the choice of $Fe^{3+}/Fe^{2+}$ affects the amount of $SiO_2$ available for normative quartz. For felsic rocks with 6 wt% $Fe_2O_3$ or less, using $Fe^{3+}/Fe^{2+}$ =.7 rather than .15 increases normative quartz by less than 2%. Few rocks in the Kamma Mountains have such high $Fe_2O_3$ so the choice of $Fe^{3+}/Fe^{2+}$ is unimportant.

The CIPW norm uses pyroxenes and olivines as the mafic silicate minerals whereas Kamma Mountains volcanics probably contain mostly biotite and amphibole as the mafic silicates. The molar ratio of Si:Fe+Mg is 1 in pyroxene but as high as 2 in amphibole (e.g., arfvedsonite; common hornblende would have a lower ratio). Consequently, a hornblende-bearing rock would have less modal quartz than a hypothetical pyroxene-bearing rock of the same chemical composition. Because of low $Fe_2O_3$, the effect is small for most felsic rocks. Normative quartz decreased 2.8% for NWRA-2603, which has 4.17 wt% $Fe_2O_3$ (normative color index of 5.22). However, the effect can be significant for more mafic rocks. Normative quartz decreased almost 10% in 422:2318.1, which has 9.36 wt% $Fe_2O_3$ + MgO (normative color index of 15.3). Such a change shifts 422:2318.1 from the dactie field to the andesite field.

Igneous rocks rarely contain corundum but CIPW norms commonly have minor normative corundum. The only aluminum-bearing minerals in the CIPW norm are the feldspars and corundum. The Al in normative corundum is probably present in modal biotite, hornblende, or other aluminous silicates in the actual rock. Alternatively, the excess Al could indicate the rock has lost K, Na, or Ca due to alteration of feldspars. In amphiboles, the molar ratio or Si:Al is at most 2:1 (e.g., pargasite) so the effect would be approximately the same as that calculated above using Si:(Fe+Mg) = 2. However, the Si:Al ratio in feldspars is 6 for orthoclase and albite and 2 for anorthite. If one makes the extreme assumption that all the normative corundum in a sample is from altered albite, the amount of $SiO_2$ which would have been contained in that feldspar (rather than in normative quartz) can be estimated by multiplying weight % corundum by 3.536. In column Q' of Table 2, this value is subtracted from the previously calculated normative quartz to arrive at a corundum-free quartz norm. The changes can be very large. For the most strongly altered sample, 445:1777.0, with 66.4% normative quartz and 14.5% normative corundum, normative quartz decreases to a reasonable but probably incorrect 15%. As shown in Table 2, rock names for several samples change. This effect is of much greater magnitude than the other effects considered above. The most appropriate QAP rock name probably lies between the two extemes of no normative corundum and no correction for aluminous mafic silicates or the possible loss of K, Na, or Ca.

In the absence of adequate petrographic data, names based on normative minerals are a reasonable approximation. However, the IUGS suggested that if the norm-based name conflicts with the mode-based name, the mode-based name takes precedence.

Notes on the TAS Classification

A chemical classification for non-pyroclastic volcanic rocks lacking modal data was formalized by the IUGS Subcommission on the Systematics of Igneous Rocks and published in 1986 (LeBas and others, 1986, J. Petrology, v. 27, p. 745-750). This classification has been widely used and continues to appear in journal articles (e.g., Econ. Geol., Nov. 1998, p. 989). Weight % $Na_2O + K_2O$ is plotted against weight % $SiO_2$, both recalculated to a volatile-free composition (i.e., LOI is eliminated from the results and the remaining oxides sum to 100%).

Assignment of "sub-root" names within the main fields of the diagram depends on various chemical criteria and mineral norms. Of relevance to Rosebud are "trachyte", which includes trachydacite (>20% normative quartz) and trachyte (<20% normative quartz), "trachyandesite", which includes benmoreite ($Na_2O - 2 > K_2O$, in wt%) and latite ($Na_2O - 2 < K_2O$, in wt%), and "basaltic trachyandesite", which includes mugearite ($Na_2O - 2 > K_2O$, in wt%) and shoshonite ($Na_2O - 2 < K_2O$, in wt%).

The major disadvantage of the TAS classification is that it does not have the same field names as the QAPF classification. Fields omitted from the TAS classification include quartz latite, quartz trachyte, and alkali-feldspar rhyolite. Thus, a direct comparison of TAS and QAPF is not possible.

Another problem in the TAS classification is the distinction between alkaline and subalkaline rocks. Boundaries between trachyte and dacite and between trachyandesite and andesite are at lower $Na_2O + K_2O$ than the alkaline – subalkaline boundary adopted by Irvine and Baragar (1971) and previously used by MacDonald, Kuno, and others. Many of the Kamma Mountains samples plot above the subalkaline boundary of TAS but below that of Irvine and Baragar (1971). Moreover, alkaline rocks were historically considered to be those with normative nepheline and none of the Kamma Mountains samples have normative nepheline.

Notes on the "Immobile" Element Classification

Winchester and Floyd (1977) proposed the use of Ti, Zr, Y, Nb, Ce, Ga, and Sc, combined in various diagrams, to classify volcanic rocks. These elements are commonly less susceptible to alteration than the major elements used in the TAS classification. Ratios of these elements are not changed by some types of alteration or by some types of metamorphism in some cases. The $Zr/TiO_2$ vs. Nb/Y diagram (ZTNY) is the most comprehensive of the diagrams of Winchester and Floyd (1977) which can be used with data available for the Kamma Mountains samples.

The ZTNY diagram has several shortcomings. It consists of numerous straight and curved lines but coordinates of the intersections are not given. It is plotted on a logarithmic scale without a grid and with only a few tick marks. The data set used to define the field boundaries omitted many important geographic regions and some volcanic rock types. Few rhyolites are included. Criteria used to identify the rock types of samples used to develop the discrimination diagrams are not stated. Overlap between some rock types and blank spaces between other rock types allow considerable flexibility in the placement of the field boundaries. An additional problem for the Kamma Mountains samples is that many samples which plot as rhyolite in ZTNY are rhyodacite (defined as $SiO_2$ <73%) inWinchester and Floyd's (1976) $SiO_2$ vs. Nb/Y diagram. Similarly, trachytes in ZTNY are comendites ($SiO_2$ >66%) and trachyandesites in ZTNY are trachytes (66%> $SiO_2$ >61%)

Fields in ZTNY are similar to those of TAS but a field for comendite/pantellerite has been added between rhyolite and trachyte; rhyodacite (including rhyolite with <73% $SiO_2$) is lumped with dacite; trachyandesite is the alkaline equivalent of rhyolite, dacite, and andesite; there is no trachydacite, basaltic trachyandesite, or trachybasalt; and there is a field for alkali basalt adjoining subalkaline basalt and trachyandesite. Consequently, the TAS and ZTNY classifications cannot be compared directly and neither matches QAPF.

Notes on Global Averages

To resolve some of the ambiguities in the chemical classifications described above and to put the Kamma Mountains results in a broader perspective, selected samples were compared to average chemical compositions for rhyolite, trachyte, dacite, and andesite compiled by LeMaitre (1976). LeMaitre's (1976) averages are based on over 500 samples for each rock type. Unfortunately, LeMaitre (1976) used each author's rock name rather than a name based on a single classification scheme. Consequently, the averages reflect a broad consensus of what geologists between 1950 and 1975 (when most of the analyses were made) thought the various rock types to be. Le Maitre (1976) calculated averages and standard deviations for $SiO_2$, $TiO_2$, $Al_2O_3$, $Fe_2O_3$, FeO, MgO, CaO, $Na_2O$, and $K_2O$. The FeO was converted to $Fe_2O_3$ for comparison with the Kamma Mountains samples. For Nb, Zr, $P_2O_5$, and Y, the much smaller data set of Winchester and Floyd (1977) was used for the averages. As mentioned above, Winchester and Floyd's (1977) data may not be very representative. Average concentrations for Ba, Rb, Sr, and Mn were not available.

Notes on Rock Names Used in this Interpretation

The "Classification System for Hand-Specimen Identification of Volcanic Rocks" developed by Dr. Mahood is not used in this interpretation for the following reasons:

1. There is no name for rocks which have sanidine and plagioclase but no quartz phenocrysts, such as the sparsely feldspar-phyric rocks and coarsely porphyritic rocks.
2. There is no unique name for rocks with hornblende and plagioclase phenocrysts or just hornblende phenocrysts such as the hornblende-plagioclase-phyric rocks and the microhornblende-phyric rocks.
3. It does not help in naming aphyric or very sparsely porphyritic rocks.
4. It doesn't allow for the possibility of rhyolite without quartz phenocrysts although the lower few hundred feet of a unit of feldspar-phyric rock with mmb (what Peter Mitchell has called the Rosebud quartz latite) appears to lack the quartz phenocryts sparsely present in the upper part.
5. It is not consistent with either QAP or TAS classifications and consequently could mislead those who don't have Dr. Mahood's table at hand for reference.

Although many of the felsic samples from the Kamma Mountains plot in the trachyte and trachydacite fields, such names carry a connotation of alkalinity which is not appropriate. In addition to high $K_2O + Na_2O$ at moderate $SiO_2$, alkaline rocks also have characteristic concentrations of the minor elements, particularly high Zr, depending on how eveolved the rocks are. The Kamma Mountains do not have the appropriate minor element concentrations. Consequently, samples which are trachyte or trachydacite are named quartz latite, consistent with QAP classification of the mineral norms. Below, concentrations of selected minor elements are compared with the more alkaline "quartz latites (trachytes)" of the various Timber Mountain – Oasis Valley caldera eruptive cycles and with the more evolved high-Si rhyolites of the Sierra La Primavera. The Timber Mountain rocks are considered "calc-alkaline to alkali-calcic" and the Sierra La Primavera rocks "mildly peralkaline".

| | Kamma Mountains quartz latites | Timber Mtn. Caldera quartz latites | Sierrra La Primavera high-Si rhyolites |
|---|---|---|---|
| **$SiO_2$ (wt%)** | 62.9-68.5 | 67.8-69.3 | 76.1-77.0 |
| **$K_2O$ (wt%)** | 3.4-5.0 | 5.3-6.0 | 4.66-4.89 |
| **$P_2O_5$ (wt%)** | .17-.36 | .08-.16 | <.01 |
| **$TiO_2$ (wt%)** | .30-.80 | .37-.56 | .09-.17 |
| **Zr (ppm)** | 170-375 | 380-1010 | 454-682 |
| **Nb (ppm)** | 17-29 | - | 65-71 |
| **Y (ppm)** | 13-42 | - | 47-76 |
| **Rb (ppm)** | 120-205 | 69-125 | 144-188 |
| **Ba (ppm)** | 910-1300 | 1200-4150 | 20 |

Broxton and others, 1989, Chemical and mineralogic trends within the Timber Mountain – Oasis Valley caldera complex, Nevada: Evidence for multiple cycles of chemical evolution in a long-lived silicic magma system; J. Geophysical Res., v. 94, no. B5, p. 5961-5985.

Mahood and Hildreth, 1983, Large partition coefficients for trace elements in high-silica rhyolites; Geochimica et Cosmochimica Acta, v. 47, p. 11-30.

## Interpretation of Results

Names based on TAS, QAP, and ZTNY for individual samples are tabulated in Table 2. To facilitate discussion and naming, samples were grouped into tentative "units" based on available field, petrographic, geochemical, and geographic data. It is likely that some "units" in the tables contain more than one rock unit and that some different "units" in the tables are actually the same rock unit. For each "unit", samples are sorted from lower to higher $SiO_2$ and what is believed to be the least altered and most representative sample(s) are highlighted in bold print.

"Dozer" aphyric rock

With few exceptions, all samples of Dozer are rhyolite according to all three classifications. Unusually low CaO (.22 wt.%) in WR49 causes it to be classified as alkali-feldspar rhyolite in QAP. Either all the other samples have had large amounts of Ca added (most do have calcite alteration), or WR49 has lost Ca, or compositions do in fact range from rhyolite to alkali-feldspar rhyolite. WR20 is classified as comendite in ZTNY because it has the highest Nb and lowest Y of all the samples. This result cannot be considered representative of the unit, particularly since Bondar-Clegg's Y results are suspect. The corundum correction, which decreases normative quartz in proportion to the amount of corundum in the norm, generally does not change the names of samples. Although all the samples are chemically altered to some degree, there is no field, petrographic, or chemical evidence to suggest that these samples were not originally rhyolite.

Comparison of Figures 2 and 3 confirms that "Dozer" is chemically more similar to rhyolite than to trachyte (average concentrations of comendite are not available). The high $Fe_2O_3$ in samples from RS-454 is probably due to hematite alteration rather than to a more mafic composition as these samples have lower MgO than most other Dozer samples. The high Y compared to typical rhyolite may be an artifact of Winchester and Floyd's (1977) limited data set or may be indicative of alkaline affinities. However, Figure 2 does show that Dozer has somewhat higher $K_2O$ and somewhat lower SiO2 (samples from RS-410 are below the standard deviation range) than is typical of rhyolite. "Dozer" samples would be considered high-K rhyolite according to the definition of Peccerillo and Taylor (1976, Contributions to Mineralogy and Petrology, v. 58, p. 63-81).

All 3 of the Lac samples have higher $SiO_2$ (even though Bondar-Clegg results are generally lower than those of Chemex), lower $Al_2O_3$, higher Nb/Zr, and higher Rb/Sr than all 4 of the Newmont samples (Table 3). WR49, which is the only Lac sample from South Ridge, is most like the Newmont samples. These differences could reflect systematic differences between the labs, alteration, or distinct rock units.

Deep Dreamland aphyric rock

This unit is the lowest volcanic unit in the Dreamland area. All samples are rhyolites in TAS and ZTNY but 3 are alkali-feldspar rhyolite in QAP. The difference in rock names is not obviously related to differences in alteration. The samples classified as alkali-feldspar rhyolite have the highest Na/Ca combined with low Ca so that their normative plagioclase composition is albite. Although all the samples have high normative corundum, the corundum correction decreases normative quartz to less than 20% for only 3 samples. As the corundum correction assumes an extreme case of alteration, use of the names quartz alkali-feldspar trachyte and quartz trachyte is probably not justified. Like the Dozer samples, this "unit" is probably best named rhyolite, or high-K rhyolite.

As for the Dozer samples, the Deep Dreamland aphyric rocks are more like average rhyolite than average trachyte and also have relatively low $SiO_2$ and high $K_2O$ (Figures 4, 5). Nb and Y concentrations are high for Winchester and Floyd's (1977) rhyolite but Zr and Nb are too low for trachytes.

The key petrogenetic parameters for these samples have narrow ranges (Table 3). Only 10*Nb/Zr is distinguishable from Newmont samples of Dozer but only barely so. The average $SiO_2$ of these samples is higher than that of the Newmont Dozer samples but this difference may not be significant.

Shallow Dreamland aphyric rock

Like the Deep Dreamland aphyric rocks, these samples are generally rhyolite by most classifications but 2 of the 3 samples are alkali-feldspar rhyolite in QAP. These 2 samples have albitic plagioclase (in the norm) but the proportion of plagioclase to K-feldspar is sufficiently low for these samples to plot in the alkali-feldspar rhyolite field in any case. These samples share the relatively low $SiO_2$ and high $K_2O$ of the other aphyric rocks and could also be referred to as high-K rhyolite.

The 2 samples from RS-450 are petrogenetically unique among the aphyric rocks due to their high Zr/Y (both unusually high Zr and low Y) and low 10*Nb/Zr. They also have relatively high $TiO_2$, Ba, Sr, and low Rb. They are probably from a flow chemically distinct from (and younger than?) the other aphyric rocks. Conversely, 426:1361.2 is chemically indistinguishable from the Deep Dreamland aphyric rocks and may, in fact, be part of the same rock unit.

Aphyric rocks with mmb

The 2 samples of aphyric rock with mafic magma blobs are rhyolite, or high-K rhyolite, but they are easily distinguishable from the other aphyric rocks by their lower $100*Zr/TiO_2$. They also have higher Zr/Y and lower 10*Nb/Zr than all the aphyric rocks but the 2 Shallow Dreamland samples from RS-450 and relatively high Al, Ca, Mg, Sr, and Zr, which may be from the mmb.

These 2 samples can be distinguished from the feldspar-phyric rocks with mmb by lower Si, higher Al, higher Zr/Y and $K_2O$/Rb, and lower $100*Zr/TiO_2$ and 10*Nb/Zr. Stratigraphically, they lie over 1000 feet below the other mmb-bearing rocks in RS-450 and could be significantly older.

Sparsely feldspar-phyric rocks

Descriptions of Lac samples are not adequate to determine if the samples have rare feldspar phenocrysts or not. However, Newmont samples which are from LBT in the North Zone (D336:105.0), brown flow/Wildrose in outcrop (NWRA-2601, 2602), and "andesite" mapped by Brady in outcrop (NWRA-2603) do have rare feldspar phenocrysts. Consequently, any Lac samples from any of these units were included. Some of these samples may not have had any phenocrysts as the distribution of phenocrysts in LBT, brown flow, and Brady andesite is not uniform. WR161, from the west end of South Ridge, is included in this "unit" because RB-7, from the same? location, was reported to have sanidine phenocrysts.

All but a few of the sparsely feldspar-phyric samples are rhyolite in QAP. With the corundum correction, all but a few are quartz latite. The low $SiO_2$ and high CaO (>3 wt.%) of the 3 andesites may be due to alteration, or natural variability, or they may be from a chemically distinct rock unit. However, WR36 is from the same mapped unit as WR17 and NWRA-2603, which are rhyolites. In TAS, most samples are rhyolite but some plot in the adjacent dacite and trachydacite fields and a few of the Lac samples have $SiO_2$ low enough to be considered trachyte (i.e., with normative quartz <20%). In ZTNY, samples are classified as rhyodacite, rhyolite, comendite, trachyandesite (most), or trachyte. Because the difference between trachyandesite and rhyolite is determined by Nb/Y and the Bondar-Clegg Y values are suspect and because the boundary between rhyolite and trachyandesite is not well constrained, the name trachyandesite is probably not appropriate. In TAS, trachyandesite has low $SiO_2$, like andesite, but that is not the case for these samples.

Comparison of selected sparsely feldspar-phyric rocks to average rhyolite and trachyte indicate significant differences in both cases (Figures 6, 7). $SiO_2$ is at the low end of, or below, the range for rhyolite and $Al_2O_3$ is at the high end, or above. Some samples have $P_2O_5$ or Y above the standard deviation for rhyolite. On the other hand, $SiO_2$ is high and $Al_2O_3$ low compared to average trachyte and Nb, Zr, and $Na_2O$ are generally below the standard derivation for trachyte.

The most appropriate name for the sparsely feldspar-phyric rocks may be quartz latite if it is desirable to distinguish these rocks from the aphyric rhyolites. $SiO_2$ and normative quartz are generally lower in these samples than in the aphyric rhyolites. If the corundum correction were halved to give a more reasonable result (equivalent to asssuming the excess aluminum is from altered plagioclase with a composition of $An_{50}$ rather than $An_5$ or is partly from hornblende), most samples would be at the lower edge of the rhyolite field but a few would be quartz latite. These samples also differ from the aphyric rhyolites in generally lower

K and higher Ca ( and consequently a higher proportion of normative plagioclase), lower Rb and higher Sr and Ba (which also suggests a higher proportion of plagioclase), and higher Fe, Mg, and Ti (and consequently a higher normative color index). The term quartz latite is not used in TAS or ZTNY so applying this name to the sparsely feldspar-phyric rocks would not conflict with those classifications. The name quartz latite is consistent with the observed phenocryst assemblage of both sanidine and plagioclase but no quartz.

In terms of the petrogenetic parameters, the sparsely feldspar-phyric rocks also differ from the aphyric rhyolites. Excluding the Shallow Dreamland samples in RS-450 and comparing only the Newmont samples, the sparsely feldspar-phyric rocks generally have higher Al, higher Zr/Y, lower 100*Zr/$TiO_2$ and 10*Nb/Zr, and lower Rb/Sr than the aphyric rhyolites. These differences and those listed above indicate the sparsely feldspar-phyric rocks are less evolved than the aphyric rhyolites. This could be due to a lesser degree of differentiation if the parent magmas were similar, to a greater degree of partial melting if the source rocks were similar, or to a greater degree of contamination by mafic magma.

"Chocolate" rocks

All the samples in this "unit" are Lac samples. They are variously described as felsite, tuff, or porphyry but all were mapped as "Chocolate" except WR55. Although Brady mapped a unit of "andesite" at the location of WR55, this "andesite" is surrounded by "Chocolate". Newmont samples of what would be considered "Chocolate" by some are grouped in the "unit" of feldspar-phyric rocks with mmb.

The "Chocolate" samples have a range of compositions. WR51 and WR3 are clearly altered. The other samples are rhyolite by most classifications. Compared to average rhyolite, WR53 has only slightly higher P but Nb and Zr are well below the range for trachyte (Figures 8 and 9).

WR5 and WR15 were collected north of Juniper Canyon and are chemically distinct from the other samples. They have lower Si and are more mafic. They are trachydacite in TAS and plot as quartz latite in QAP after the corundum correction. They are similar to some of the intrusions discussed below.

WR39 is also chemically distinct and may be from a rock type different from the other samples. It has lower Al, Fe, K, and Zr but higher P, Ti, and Y and relatively high Si. Because of the high Ti and somewhat low Zr, it plots as dacite/rhyodacite in ZTNY.

Compositions of the Chocolate samples overlap with but are generally intermediate between those of the aphyric rocks and those of the sparsely feldspar-phyric rocks. Compared to the aphyric rocks, Chocolate samples have lower 100*Zr/$TiO_2$ and 10*Nb/Zr but higher Ti, P and Ba. Compared to the sparsely feldspar-phyric rocks, they have generally higher Si, K, and Rb.

Feldspar-phyric rock with mmb

All the samples in this unit are Newmont samples from Dreamland and Lucky Boy drill core. They may be from the Chocolate Formation of some workers but their relation to Lac's "Chocolate" samples (above) has not been determined. Samples 445:1777.0, 1793.6, and 1853.4 are moderately to strongly altered and were collected for comparison of alteration with 445:1906.0 and 1864.3, which have only calcite alteration. All the unaltered to weakly altered samples are rhyolites by all classifications. The presence of sanidine and plagioclase phenocrysts and rare quartz supports use of the term rhyolite.

Feldspar-phyric rocks with mmb differ from average rhyolite only in having unusually high Y and relatively low Si but differ substantially from trachyte (Figures 8, 9). Low Na in some samples and relatively high Ca in most compared to rhyolite may be due to alteration.

The feldspar-phyric rocks with mmb are compositionally similar to "Chocolate" samples but with some significant differences. Al, Na, P, and Ba are generally lower in the feldspar-phyric rocks with mmb and 10*Nb/Zr is higher. These samples are more similar to the aphyric rocks than to the "Chocolate" samples but can be distinguished from aphyric rocks by lower Zr/Y and 100*Zr/$TiO_2$ (generally lower Zr and Y but higher Ti). They also generally have higher Na and Ca than the aphyric rocks. In contrast, there is a very clear distinction between the feldspar-phyric rocks with mmb and the aphyric rocks with mmb, which have lower Si and Nb/Zr but higher Al, Na, Ti, P, and Zr/Y (compare to 450:1811.2 in Figures 8, 9).

All the "units" considered above are generally rhyolite with broadly similar compositions. However, chemical differences between them cannot be explained by simple differentiation because the most evolved rocks, the aphyric rocks, are apparently the oldest. Nor can the differences be explained by a simple trend of increasing contamination by mafic magma through time although such contamination did occur.

<u>Porphyritic "Chocolate" or intrusions</u>

Samples in this "unit" are from different rock units and generalizations are not possible. WR61 is apparently from the plagioclase-phyric "gorilla" intrusion which Peter Mitchell has identified north of the Mother Lode vein. WR21 may be from a similar rock on the east side of Rosebud Peak if the mapped sample location is slightly off. Due to its relatively low Si, WR61 is quartz latite (QAP) or trachyte (TAS). It has an even less evolved, more mafic character than the low-Si samples of the sparsely feldspar-phyric "unit", e.g., WR12, WR36, and WR6. Although it has higher K than these samples, it also has higher Ti, P, and normative color index and lower 100*Zr/$TiO_2$. However, it could be from a similar source or similar parent magma.

WR47 is a biotite-plagioclase-phyric rock (based on the description of RB-11, which was collected nearby) from Big Chocolate Hill. As this has been mapped as "Chocolate", it is important to note how different this sample is from other Lac "Chocolate" samples and from feldspar-phyric rock with mmb. WR47 is classified as trachyte (TAS) or rhyolite (QAP). WR47 is more similar to average rhyolite than to average trachyte or dacite (Figures 10, 11, 12) but does have Si lower than the standard deviation and has high P and Ca. K, Na, P, Ba, Sr, and Zr are similar to "Chocolate" samples but Si and 100*Zr/$TiO_2$ are lower and Ca, Fe, Mg, Ti, and Nb/Zr are higher. In terms of its lower Si and more mafic character, WR47 is more like sparsely feldspar-phyric samples than like "Chocolate" samples. WR47 differs from the sparsely feldspar-phyric rocks in having lower Zr/Y and higher 10*Nb/Zr due to relatively low Zr.

WR4 is from what has been mapped as a small plug south of USMM212 at North Equinox. It has a few percent feldspar phenocrysts which are generally too iron-stained to identify. Apart from the basalts, it is one of the least siliceous and most mafic samples in the database. It is classified as andesite (QAP) or trachyte (TAS). The high $K_2O$ is well above the range for normal andesite and even for dacite but Nb and Zr are too low for trachyte (Figures 13, 14, 15). Compositionally, it is similar to WR61 but has even less Si and is slightly more mafic. As WR4 plots close to the quartz latite field in QAP and could have gained Ca, the best compromise name may be quartz latite (identifying sandine phenocysts in the rock would confirm this choice).

West Kamma Peak intrusions

The 2 samples of West Kamma Peak intrusions differ in many respects from each other but the high Zr and low Y of both samples indicates they have more alkaline affinities than other samples from the Kamma Mountains. They have the highest believable Zr/Y (i.e., not due to below detection Y) of all the felsic rocks which are not obviously altered. They also differ from most other felsic rocks in the Kamma Mountains in having approximately equal $K_2O$ and $Na_2O$. They are classified as andesite or rhyolite (or quartz latite after the corundum correction) in QAP, as trachyte or trachydacite in TAS and as trachyandesite or possibly comendite in ZTNY. Except for low Nb and slightly low Y, WR37 comes reasonably close to matching average trachyte, certainly closer than any other plotted samples (Figures 10, 11, 12). Compared to average rhyolite, it has high P, slightly high Zr and Al, and Si below the standard deviation. Trachydacite may be appropriate but the only significant difference between WR37 and WR47, the Big Chocolate quartz latite, is its higher Zr. The name quartz latite is probably better because it emphasizes the similarities with the other quartz latite samples.

Lantern intrusions

The 3 samples of Lantern intrusions have generally similar compositions although WR44 is from the west edge of the Kamma Mountains, over 1 mile from the other 2 samples. They are all rhyolite in QAP and TAS but because of low Zr and relatively high Ti, they are dacite or trachydacite in ZTNY. WR40 matches average rhyolite except for high P and Y.

The Lantern samples are similar to the aphyric rocks but they have lower K, considerably lower Zr, and higher Ca, Ba, and P. They are slightly more mafic. Although still “high-K” according to Peccerillo and Taylor’s (1976) classification, the Lantern samples have lower $K_2O$ and are closer to average rhyolite than are the aphyric rocks. As the Lantern intrusions occur on the east side of the Kamma Mountains in what may be “Chocolate”, they may be relatively young intrusions.

Coarsely porphyritic rocks

The coarsely prophyritic rocks from RS-444 are all rhyolites. With greater than 6.5% $K_2O$, they are (very) high-K rhyolites. They have sanidine and plagioclase but no quartz phenocrysts. They exceed the standard deviation ranges for rhyolite for K, Nb, and Zr by small amounts and also have high Y (Figures 10, 11, 12). Relatively low Na and high Ca may be due to alteration.

The compositions of the coarsely porphyritic rocks are most similar to those for the aphyric rocks and the aphyric rocks with mmb. Si, Al, Zr/Y, and 10*Nb/Zr are similar to those for the aphyric rocks with mmb but P and Ti are lower and Ba, Rb, Nb, Zr, and Y are higher. $100*Zr/TiO_2$ is intermediate between that of the aphyric rocks and that of the aphyric rocks with mmb.

The unusually high concentrations of K, Rb, Nb, Zr, and Y may be due to differentiation but Si is no higher than in the aphyric or sparsely feldspar-phyric rocks. Lower Ca, Na, Ba, Sr, Fe, Mg, Ti, and P than in the sparsely feldspar-phyric rocks is suggestive of differentiation of the coarsely porphyritic rocks from a relatively mafic, low-Si, sparsely feldspar-phyric rock or similar parent magma. As the coarsely porphyritic rocks are intrusive, the observed age relations are consistent with such a hypothesis. Alternatively, the coarsely porphyritic rocks could be related to more mafic quartz latite intrusions such as WR61.

The coarsely porphyritic samples from RS-446 are compositionally quite different from the others. These 2 samples are more strongly altered but they could be from a different rock type. Both have less than 3.7% $K_2O$ and are dacites in TAS. The 2 RS-446 samples are also much more mafic than the RS-444 samples. However, similar concentrations of the less mobile elements, P, Ti, Nb, Zr, and Y as well as Si and Al and similar Zr/Y, 100*Zr/$TiO_2$, and Nb/Zr suggest that the samples may actually be from the same unit as the RS-444 samples. If that is the case, green clay alteration must have caused a strong depletion of K but an enrichment in Fe and Mg. Na, Ba, and Rb were also depleted but Sr was enriched compared to the RS-444 samples.

Hornblende-plagioclase-phyric rock

The hornblende-plagioclase-phyric rocks, biotite-plagioclase-phyric rocks, and microhornblende-phyric rocks are difficult to classify because there are only 1 or 2 samples for each "unit", compositions plot close to field boundaries, and compositions may have been significantly modified by calcite alteration.

The hornblende-plagioclase-phyric rocks have about 20% plagioclase and 5-15% hornblende phenocrysts but plagioclase has been extensively replaced by calcite and hornblende by green clay. The 2 samples are andesite and ryholite in QAP and trachyte and dacite in TAS. Although ZTNY indicates that they are trachyandesite, this seems unlikely with >63% $SiO_2$ and only 190 ppm Zr. Although there are significant differences in major and some minor element concentrations, the similar color indices and P, Ti, Zr and Nb suggests the 2 samples are from the same unit.

Comparisons of 446:2658.3 with average trachyte, andesite, and dacite indicate K, Nb, and Zr are too low for trachyte, Ca, Fe, and Mg too low and Si, Na, Nb, and Zr too high for andesite, and Nb and Na too high and Ca too low for dacite (Figures 13, 14, 15). Tentative identification of oligoclase in 446:2658.3 suggests the rock is not andesite. One of many plausible scenarios is that 446:2658.3 lost Ca and gained Na during plagioclase replacement, in which case it should be dacite in QAP as it is in TAS. 422.1:1959.6 may have preserved nearly original concentrations of Na and Ca (which are within one standard deviation of the dacite average) but lost Si during green clay alteration, in which case it would be dacite in QAP (still trachyte in TAS). In any case, these samples clearly have a more intermediate character (more mafic, more plagioclase) than the felsic rocks discussed above.

In the review of RS-446 core during Dr. Mahood's visit, Peter Mitchell commented that this unit resembles what he has been calling White Alps porphyry.

Biotite-plagioclase-phyric rock

The one sample of this unit is affected by weak argillic and green clay alteration and by calcite alteration. It is rhyolite in all classifications but ZTNY, where it is dacite. The low $K_2O$ of 1.65%, Rb of 42 ppm, and Zr of 205 ppm combined with 75% $SiO_2$ and high Si/Al are suspicious. The phenocryst assemblage of plagioclase without sanidine or quartz would be highly unusual for rhyolite. As shown in Figure 13, 422.1:1985.1 may be an altered dacite where conserved elements such as Al, P, Ti, and Zr were diluted by the addition of Si. Some

K, Ca, Fe, and Mg may also have been lost. Because of the ambiguities in the alteration history and original composition of this sample, the name rhyodacite may be suitable.

Microhornblende-phyric rock

In addition to calcite and weak green clay alteration, the 2 samples of this "unit" have amygdales filled with calcite, chlorite (and possibly another green mineral), and chalcedony. They are dacite or quartz latite in QAP and dacite or trachyte in TAS, respectively. Both are andesites in ZTNY. K, Nb, and Zr are clearly too low for these rocks to be trachyte (Figure 15). Ca, Fe, and Y are lower than and Nb higher than in average andesite (Figure 14). Compared to average dacite, the samples have slightly higher P and slightly lower Si, Zr, Y, and Ca (Figure 13). Although K and Si are at the upper end of the range for average andesite and for andesite in TAS, these samples are clearly more mafic, with color indices of 11-15 and $100*Zr/TiO_2$ less than 2, than all the other samples considered above. Andesite is probably the best name for these samples. The 2 samples straddle the boundary between andesite and high-K andesite, according to Peccerillo and Taylor (1976).

Dreamland vitric-lithic lapilli-ash tuff

424:2009.6 does not appear to be significantly altered in hand sample or thin section (except for the replacement of glass by green clay) but it has an ususual composition. Even allowing for extensive alteration and up to 3% exotic lithic fragments, this sample has little in common with the other Kamma Mountains samples. It also differs significantly from Bud samples WR32, 46, and 54. Although WR32 has similar Si, Ti, Nb, and Sr, it has lower K and Rb and higher Ca, Na, P, Ba, and Zr. 424:2009.6 is rhyolite in all classifications. $SiO_2$ is high enough for 424:2009.6 to be considered high-Si rhyolite. Although the Dreamland tuff is devoid of phenocrysts, the composition is not too different from that of the late-erupted Bishop Tuff (Mahood and Hildreth, 1983). It is clearly a subalkaline, metaluminous rather than alkaline rock. 424:2009.6 is probably not genetically related to the flows and intrusions described above.

Barrel Springs rocks

2 samples of volcanic rocks were collected from the Barrel Springs area. They fail the chemical tests for alteration and because they are described as "white" or "siliceous", they may be strongly altered. Very different major element compositions but similar P, Ti, Nb, and Zr in both samples also suggest alteration. P, Ti, Nb, and Zr and some other element concentrations are similar to those of the Dreamland tuff so these samples might also be high-Si rhyolite. I think Peter Mitchell collected samples from the area for analysis so he may have more reliable data.

Wildrose Canyon vitrophyre

This sample is a rhyolite in all classifications but its composition differs substantially from those of other Kamma Mountains samples. Peter Mitchell recently collected a sample of this rock for analysis and may be able to offer additional insight into its origin and significance.

Other felsic rocks

All the samples in this group but WR30 fail the chemical tests for alteration and little is known about the samples. WR52 is described as a vitrophyre but it is unlike the Wildrose Canyon vitrophyre. With 10.5% LOI, interpretation of the chemical data is difficult. WR23 is a Si-rich rock with high K but low Zr. Low Al and Na much lower than K suggest it may be strongly altered. WR65 has a very unusual composition with very high Si, low K and Al and more MgO than $Fe_2O_3$. $TiO_2$ of .24% and Zr of 225 ppm suggest it may have been an intermediate rock.

WR30 was collected from the dark volcanic outcrops north of the junction of the Jungo road with the Rosebud mine road. Although described as an intrusion, the volcanic rock is appeerently overlain by muddy, matrix-supported conglomerate south of the Jungo road and faulted against similar rocks on its northen contact. There is propylitic alteration (with epidote) along the fault.

WR30 is rhyolite in QAP and trachydacite close to the rhyolite boundary in TAS. It is similar to the quartz latite of West Kamma Peak (WR37) but has much higher Ti and much lower Zr. As WR30 has less Si and K than rhyolites of the Kamma Moutains and is quartz latite (barely) in QAP after the corundum correction, the most appropriate name may be quartz latite. If the Zr and Ti concentrations are not altered, WR30 has a unique composition.

Andesite and basalt

SuK-97-3, F-98-1, and WR29 are all from a locally coarsely porphyritic basalt on the east flank of the Kamma Mountains and at least SuK-97-3 and F-98-1 are quite fresh. All plot in the andesite/basalt field of QAP. WR29 could be considered andesite because of its high $SiO_2$ (>52%, but barely) and low normative color index (<35%), according to the recommendations of the IUGS Subcommission on the Systematics of Igneous Rocks. In TAS, SuK-97-3 is squarely within the basalt field but the others are close to or barely in the adjacent field of basaltic andesite. Olivine and augite are relatively common in thin section. Basalt is the most appropriate name for the unit as a whole.

SK-98-1 is from an aphyric basalt with rare olivine phenocrysts east of the Rosebud mine road. Because it contains quartz xenocrysts, its composition may have been contaminated by assimilation of felsic/granitic rocks and possibly phyllite. It has about the same $K_2O + Na_2O$ as F-98-1 and WR29 but has lower Si so it plots as basalt close to the trachybasalt field in TAS.

These basalts east of the Kamma Mountain are apparently younger than the felsic volcanic rocks of the Kamma Mountains and would have no magmatic affiliation with them.

WR8 and WR33 are the only samples of what Brady named the Oscar Andesite. Unfortunately, both are chemically altered. WR8 plots in the basalt/andesite field in QAP and, because of $SiO_2$ >52% and color index <35%, it is andesite. In TAS, it plots near the boundary of basaltic trachyandesite and basaltic andesite. As $Na_2O$ is less than 2% higher than $K_2O$, the name is shoshonite. WR8 does not match average andesite closely but it matches dacite and trachyte even less well (Figures 13, 14, 15).

WR33 is close to WR8 but is north of the Rosebud Canyon road rather than south of it. It has significantly higher Si, Na, and Fe, but lower K, Ca, and Mg. Differences between the 2 samples may be due to alteration or they may originally have had different compositions. WR33 is an andesite in QAP for the same reasons as WR8 but plots in the trachyandesite field of TAS. Because $Na_2O$ in WR33 is more than 2% higher than $K_2O$, it is benmoreite.

WR8 and WR33 are alkali basalt in ZTNY but are close to the subalkaline boundary in TAS. The relatively high $K_2O$ and $Na_2O$ are not matched by high Ti, Zr, Nb, and Y so alkaline names are probably not appropriate. WR8 and WR33 are not as evolved as microhornblende-phyric andesite near the bottom of RS-422 so the name basaltic andesite (defined as 52-57% $SiO_2$ in TAS) would make a useful distinction. They are high-K basaltic andesite in the classification of Peccerillo and Taylor (1976).

It is not clear what WR28 is a sample of but the sample extends the range of compositions for generally intermediate rocks in the Kamma Mountains. It is andesite in QAP and trachyandesite (variety latite) in TAS. The composition is probably significantly altered but WR28 has less Si and more P and Ti than microhornblende-phyric andesite. With 59% $SiO_2$ and only 95 ppm Zr, andesite is probably the more appropriate name.

## Summary

The names and key geochemical characteristics of the various “units” are summarized in the table below. Many of the rock “units” are not chemically distinguishable with the available data but some are. The parameters listed are relatively insensitive to weak alteration but small changes in $SiO_2$, $K_2O$ and the normative color index, in particular, are possible.

**Table 5. Summary of Rock Names and Critical Geochemical Parameters**

| “Unit” | Rock Name | $SiO_2$ | $Al_2O_3$ | $K_2O$ | Norm. Color Index | $P_2O_5$ | $TiO_2$ | Zr | Zr/Y^ | 100*Zr/ $TiO_2$ | 10*Nb/ Zr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| “Dozer” aphyric | rhyolite | 69.5-73 | 15.0-15.5 | 5.0-6.0 | 2-4 | .03-.04 | .12 | 260-290 | 6.5 | 23-24 | .8-.9 |
| Deep Dreamland aphyric | rhyolite<br>af rhyolite# | 71-73.5 | 15.0-16.5 | 5.3-5.8 | 2-4 | .03-.06 | .10-.12 | 260-300 | 6.2-6.6 | 23-26 | .9-1.0 |
| Shallow Dreamland aphyric[1] | rhyolite<br>af rhyolite | 70-73 | 15.7-16.2 | 4.4-5.4 | 3-4 | .08-.09 | .17-.18 | 390-420 | 11-13 | 23.2 | .52 |
| Sparsely feldspar phyric | rhyolite - quartz latite | 67-71.5 | 15.5-16.4 | 4.4-5.9 | 2-6 | .08-.22 | .17-.42 | 270-350 | 8-10<br>(11-18 | 7-20 | .6-.75 |
| Sparsely feldphyric (mafic)[2] | quartz latite | 64-67 | 16.7-17.6 | 3.4-4.0 | 7-8 | .25-.31 | .60-.70 | 255-285 | (12-20) | 4.0-4.5 | .78-.9 |
| “Chocolate” | rhyolite | 70-71.5 | 15.3-15.8 | 5.1-5.7 | 2.5-4 | .12-.16 | .17-.22 | 215-360 | (6-10) | 11-17 | .6-.85 |
| Feldspar-phyric w/ mmb | rhyolite | 71-74 | 14.5-15.6 | 5.3-6.3 | 2.5-3.5 | .05-.06 | .16-.17 | 210-250 | 5.5-6.1 | 13-15.5 | 1.0-1.1 |
| Aphyric w/ mmb | rhyolite | 69-70 | 16.0-16.5 | 5.15 | 3.5-4.8 | .08-.09 | .28-.30 | 300-320 | 7.5-7.8 | 10.4-10.7 | .73-.77 |
| Dreamland Tuff 424:2009.6 | high-Si rhyolite | 75.8 | 14.0 | 4.7 | 3.5 | .06 | .16 | 186 | 5.8 | 11.6 | .97 |
| Coarsely porphyritic | high-K rhyolite | 69.5-71 | 16.0-16.5 | 6.7-7.1 | 2.3-3.3 | .03-.05 | .21-.22 | 360-390 | 7-10 | 16.5-17.5 | .73-.83 |
| “Gorilla” WR61 | quartz latite | 63.6 | 16.4 | 4.3 | 9.3 | .34 | .75 | 245 | (7.4) | 3.3 | 1.05 |
| Big Chocolate Hill WR47 | quartz latite | 68.4 | 15.3 | 5.0 | 5.8 | .17 | .30 | 270 | (9.0) | 9.0 | .93 |
| Jungo Jct. WR30 | quartz latite | 68.5 | 15.9 | 4.8 | 4.7 | .17 | .43 | 170 | (7.4) | 4.0 | 1.0 |
| N. Equinox WR4 | quartz latite | 62.9 | 16.3 | 4.2 | 10 | .36 | .79 | 215 | (8.6) | 2.7 | .93 |
| W. Kamma Peak WR37 | quartz latite | 68.5 | 16.1 | 4.7 | 4.8 | .17 | .26 | 375 | (17.9) | 14.4 | .60 |
| Lantern WR40 | rhyolite | 70.2 | 15.1 | 4.7 | 4.4 | .14 | .27 | 220 | (5.6) | 8.1 | 1.05 |
| Hbl+plag-phyric | dacite | 65-69 | 16-18.5 | 1.4-3.8 | 5-6 | .21-.24 | .39-.42 | 190 | 10-14 | 4.6-4.8 | .73-.74 |
| Hbl+bio+plag-phyric(1985.1) | rhyodacite? | 75.2 | 14.2 | 1.7 | 2.4 | .10 | .27 | 205 | 6.0 | 7.6 | 1.1 |
| Microhbl-phyric | andesite | 63-63.5 | 16.4-17.5 | 2.0-2.6 | 11.5-15.5 | .27 | .68-.74 | 125-135 | 9.4 | 1.8 | .6 |
| “Oscar Andesite” | basaltic andesite | 55.4-56.3 | 16.4-16.9 | 1.75-1.90 | 19-23 | .43-.46 | 1.05 | 80-105 | (27-35) | .8-1.0 | 1.1-1.4 |
| Basalt | basalt | 48-52 | 15.4-16.5 | 1.0-1.8 | 25-39 | .30-.40 | 1.9-2.1 | 130-165 | 5-6<br>(11) | .8 | .6-.75 |

^ Bondar-Clegg results are parenthesized
\# alkali-feldspar rhyolite

[1] includes only the 2 RS-540 samples
[2] includes samples WR12, WR36, and WR6

The following attempt at summarizing the magmatic history of the Kamma Mountains is necessarily simplistic and tentative. Obviously, data are not available for all units and the effects of alteration are not completely understood. Stratigraphic and cross-cutting relations are also not completely understood. Grouping the samples into geologically more meaningful units would be useful.

I plotted element vs. element scatter diagrams in an attempt to identify genetic relations between the various "units". However, that was before some of the most recent results and before I had achieved the somewhat consistent grouping of samples into the present "units". I made no attempt to exclude altered and atypical samples. Distinctions between magmatically unrelated rocks were not obvious at that time even on plots of the less mobile elements. A more careful choice of samples to plot might yield more interpretible results.

The oldest volcanic rocks in the Kamma Mountains have intermediate compositions. These include the usually(?) aphyric basaltic andesite of the Oscar Andesite and the strongly porphyritic rocks in the lower parts of RS-422 and RS-446, e.g., hornblende-biotite-plagioclase-phyric rhyodacite(?), hornblende-plagioclase-phyric dacite and amygdaloidal, microhornblende-phyric andesite. However, in both places where these rocks occur, there is evidence for intrusions of intermediate compositions. All the intermediate rocks may be older than the bulk of the aphyric rocks or some may be older and some younger. In TAS, some intermediate samples are trachyte, shoshonite, or benmoreite.

The ignimbrite identified at Barrel Springs by Peter Mitchell may be older than the intermediate rocks but I haven't tried to relate the two stratigraphically.

The Dozer and the aphyric rocks at Dreamland are rhyolite and alkali-feldspar rhyolite flows. Recently, very rare feldspar phenocrysts have been recognized in Dozer. 454:197.3 has such phenocrysts but it does not differ chemically from other samples of Dozer. The aphyric rocks differ from average rhyolite in having $K_2O$ >5% (meeting the definition of high-K rhyolite) and relatively low $SiO_2$, generally <72% (volatile-free). There is no evidence that the aphyric rocks are genetically related to the intermediate rocks but they may be.

Younger than the aphyric rocks is a suite of slightly less siliceous and slightly more mafic rhyolite flows which locally have rare sanidine and plagioclase phenocrysts and very rarely mafic magma blobs (e.g., mmb occur in D326:105.0, WR45, and NWRA-2603). A few of the flows are quartz latite. These rocks generally have higher Zr than the aphyric rocks and consequently higher Zr/Y but lower $Zr/TiO_2$ and Nb/Zr. In TAS, these rocks are variously classified as trachyte, trachydacite, and rhyolite depending on how much $SiO_2$ they have (all have $K_2O + Na_2O$ = 7.9-8.8%). These rocks have been called LBT, Wildrose, brown flow, andesite (including Brady Andesite), Chocolate (on early Lac maps), intrusions, and even Dozer (e.g., WR161). "Chocolate" samples cannot be distinguished from these flows. There are probably no significant chemical differences between any of these misbegotten, so-called "stratigraphic" units.

At one or more times during the eruption of the sparsely-feldspar-phyric flows, thin tuffs were deposited in the Kamma Mountains. If it is not altered, one such tuff is high-Si rhyolite. It is probably not chemically related to the sparsely feldspar-phyric flows, or any other volcanic rocks, in the Kamma Mountains.

There is a compositionally variable series of small intrusions and possibly flows which are generally less siliceous ($\leq$ 68.5% $SiO_2$) and more mafic (normative color index >4.5%) than the bulk of the sparsely feldspar-phyric rocks. In fact, this series overlaps the compositional range of the sparsely feldspar-phyric rocks and is probably derived from the same or similar parent magmas. For consistency, all these rocks are named quartz latite although some may be rhyolite and possibly andesite. Some of these rocks are porphyritic but the phenocryst assemblages have not been described. In TAS, these rocks are typically trachyte or trachyandesite. If the duration of magmatism for the quartz latites and sparsely feldspar-phyric rhyolites is the same, then a chemical distinction between them is probably not meaningful.

The age of the Lantern rhyolite intrusion(s) is not known but it seems to be compositionally distinct from the quartz latites. It has 70% $SiO_2$ but unusually low Zr/Y and high Nb/Zr. It may represent a distinct episode of volcanism.

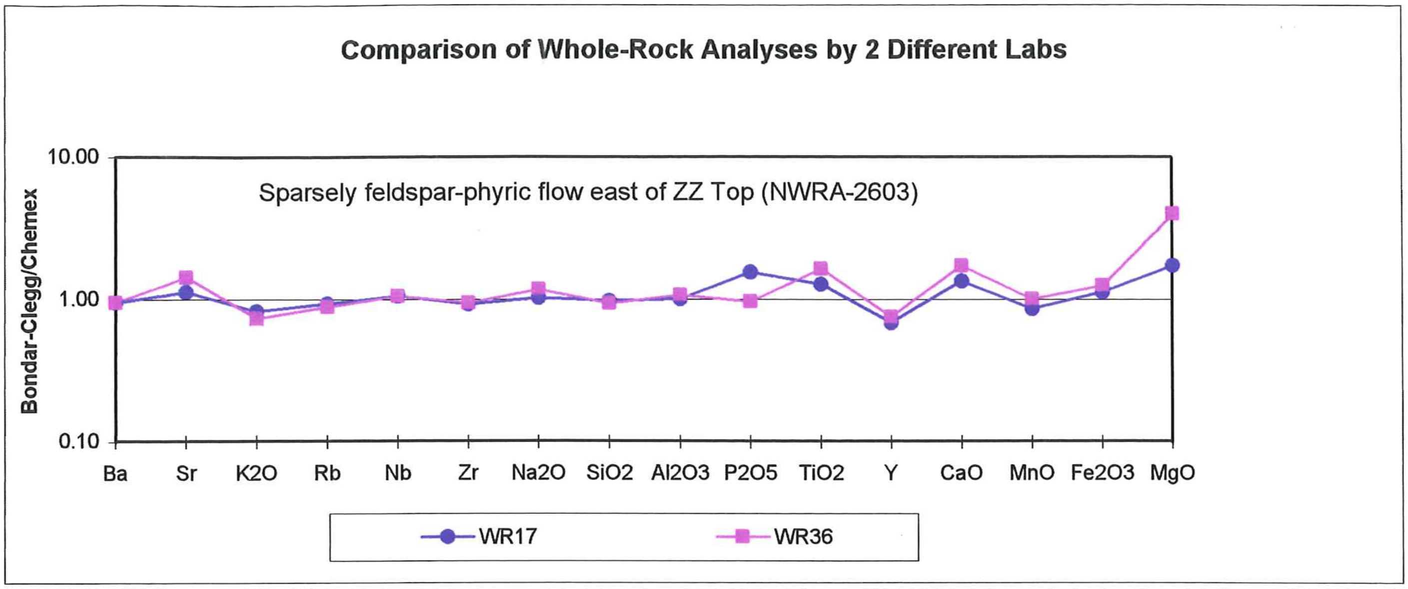
Succeeding and possibly overlapping with eruption of the sparsely feldspar-phyric rhyolite and related quartz latite was intrusion and eruption of feldspar-phyric rhyolite flows with mafic magma blobs. These rocks have sanidine and plagioclase phenocrysts and locally biotite, quartz, or rarely hornblende. These rocks have slightly higher $SiO_2$ and lower Zr than the sparsely feldspar-phyric rocks and can be easily distinguished by their lower P and Zr/Y but higher Nb/Zr. Al is also generally lower. They have lower Zr/Y and Zr/$TiO_2$ and higher Nb/Zr than the aphyric rocks. They may be a more differentiated but also more contaminated (by mafic magma) version of magma similar to the sparsely feldspar-phyric rocks but any genetic relations with older volcanic rocks are not simple.

Intrusion of coarsely porphyritic rhyolite with sanidine and plagioclase phenocrysts probably followed emplacement of the feldspar-phyric rhyolite with mmb but the temporal relations have not been well determined. These rocks have unusually high K, Rb, Nb, Zr, and Y and may have differentiated from mafic quartz latite or sparsely feldspar-phyric quartz latite magma.

The Kamma Mountains Group is overlain by olivine-augite-plagioclase basalt flow(s) whose composition approaches basaltic andesite and basaltic trachyandesite in TAS. These rocks are normative olivine tholeiite and quartz tholeiite. Locally, this basalt is strongly vesicular or has coarse plagioclase phenocrysts. A possibly younger olivine-phyric basalt with quartz xenocrysts has 2% normative nepheline and is an alkali olivine basalt.

Although most of the felsic volcanic rocks of the Kamma Mountains have grossly similar compositions they cannot be easily related to one another simply by differentiation or variable degrees of mixing with a single mafic magma. Other processes such as addition of successive magma batches to a crustal magma chamber, mixing of felsic magmas from different sources, or mixing with different types of mafic magmas may also have been involved.

Strongly differentiated, phenocryst-rich volcanic rocks are not present in the Kamma Mountains. There is a thin high-Si rhyolite tuff but it has no phenocrysts and it may have been erupted far away. The coarsely porphyritic rhyolite has minor element enrichments suggestive of differentiation but it has only 71% $SiO_2$ and lacks quartz phenocrysts. This unit is commonly altered and some mineralization may be related to it. However, there have been few opportunities for strong magmatic concentration of volatiles and metals in the Kamma Mountains Group. Syn-volcanic normal faulting may have allowed magmas to reach the surface without prolonged residence in crustal magma chambers. However, there may be younger intrusions like the sanidine+quartz-phyric rhyolite at Majuba Hill, which could generate gold-rich fluids or drive long-lived hydrothermal systems, in the basement below or near the Kamma Mountains.


Comparison of Whole-Rock Analyses by 2 Different Labs
Sparsely feldspar-phyric flow east of ZZ Top (NWRA-2603)
Bondar-Clegg/Chemex
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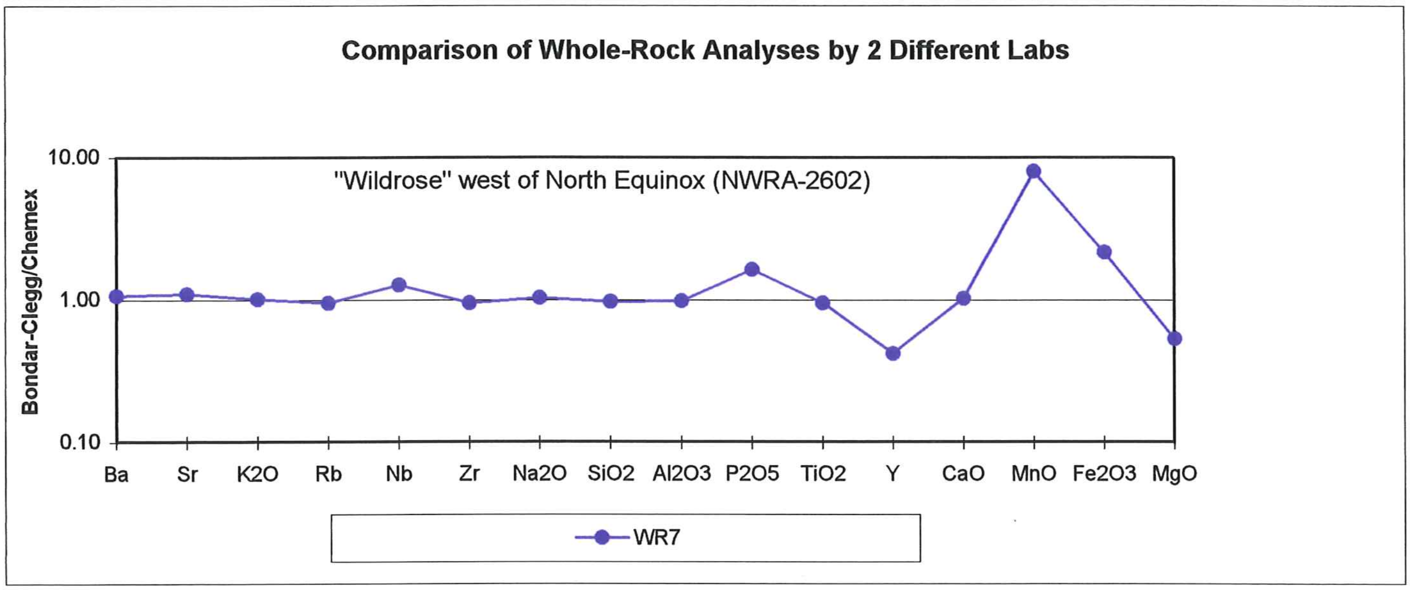
1.00
0.10
Ba Sr K2O Rb Nb Zr Na2O SiO2 Al2O3 P2O5 TiO2 Y CaO MnO Fe2O3 MgO
WR17
WR36


Comparison of Whole-Rock Analyses by 2 Different Labs
"Wildrose" west of North Equinox (NWRA-2602)
Bondar-Clegg/Chemex
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1.00
0.10
Ba Sr K2O Rb Nb Zr Na2O SiO2 Al2O3 P2O5 TiO2 Y CaO MnO Fe2O3 MgO
WR7

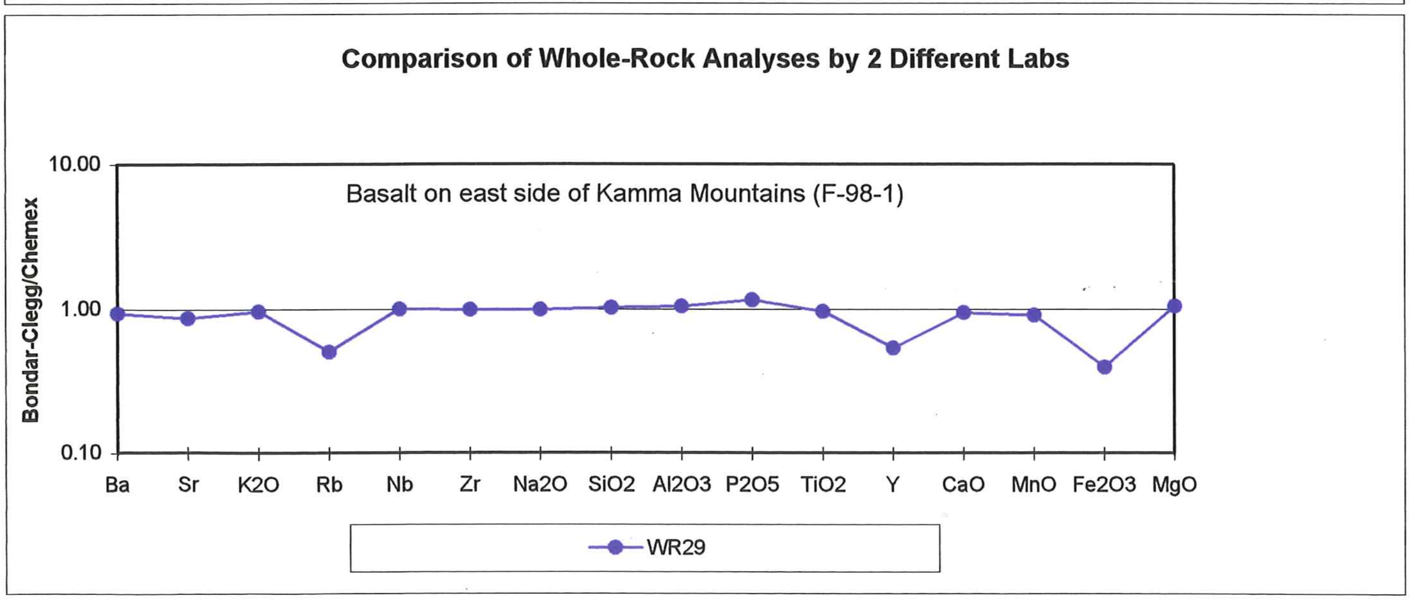

Comparison of Whole-Rock Analyses by 2 Different Labs
Basalt on east side of Kamma Mountains (F-98-1)
Bondar-Clegg/Chemex
10.00
1.00
0.10
Ba Sr K2O Rb Nb Zr Na2O SiO2 Al2O3 P2O5 TiO2 Y CaO MnO Fe2O3 MgO
WR29

Figure 1.

## Figure 2. Comparison of Elements for

## "Dozer" aphyric rocks

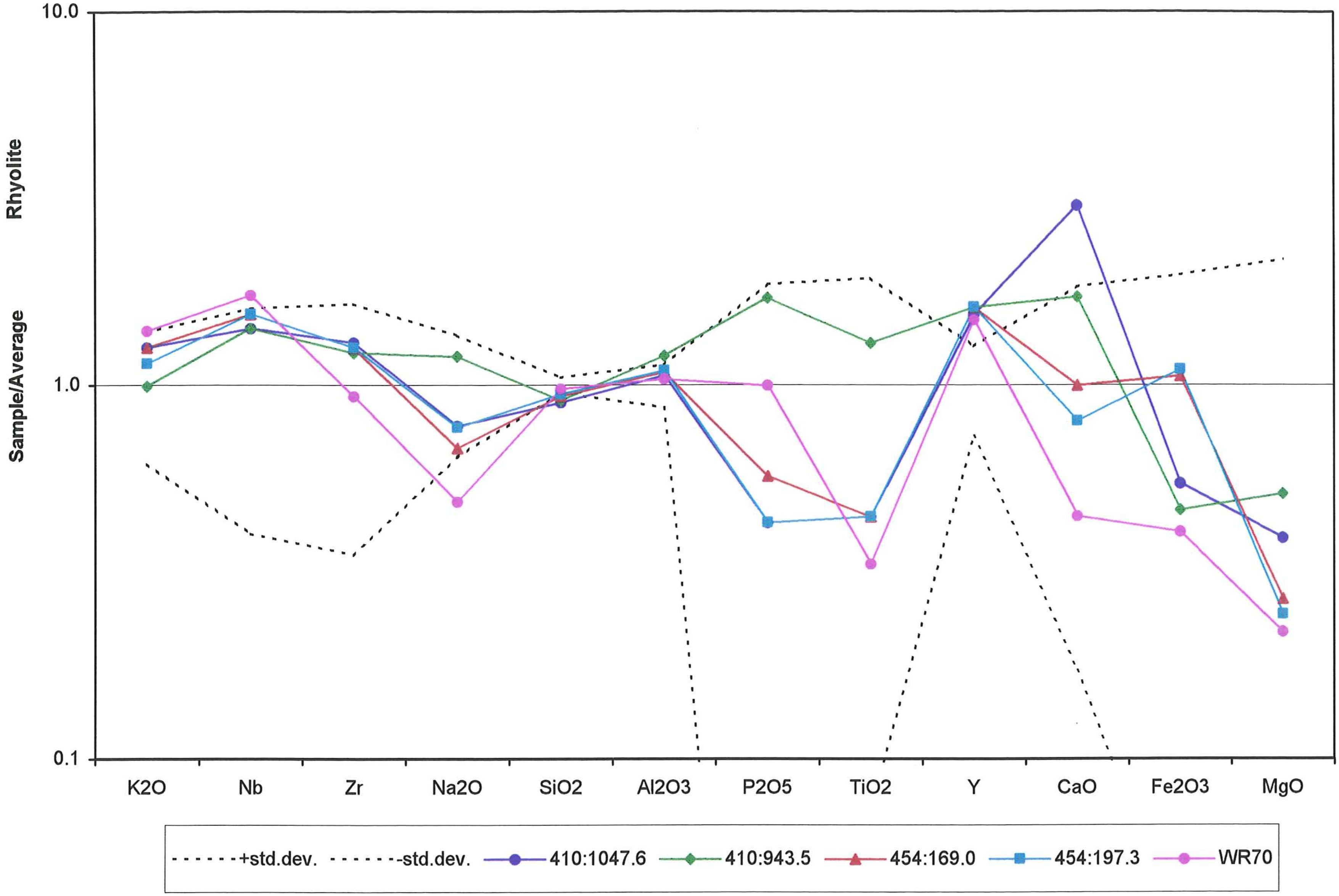
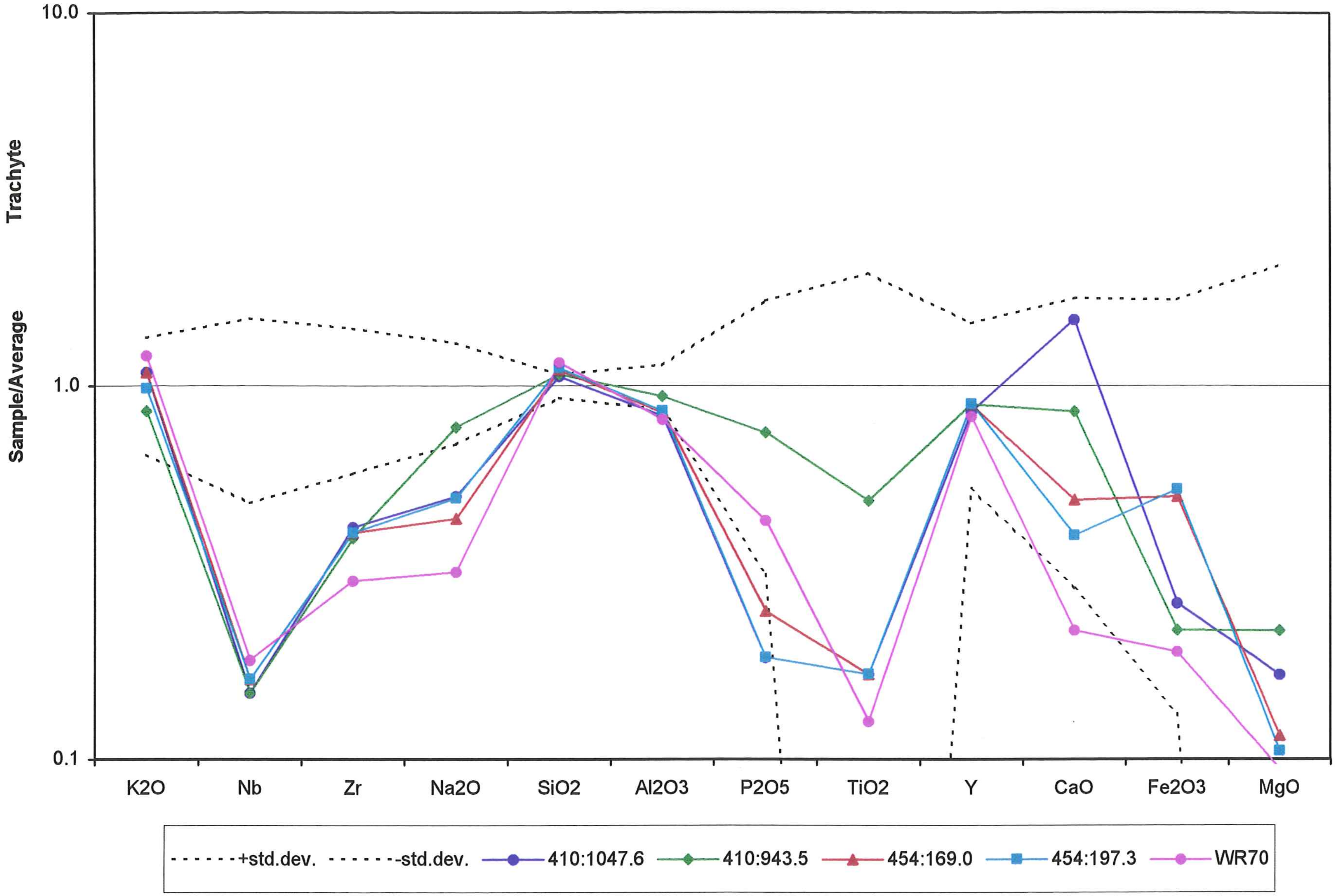


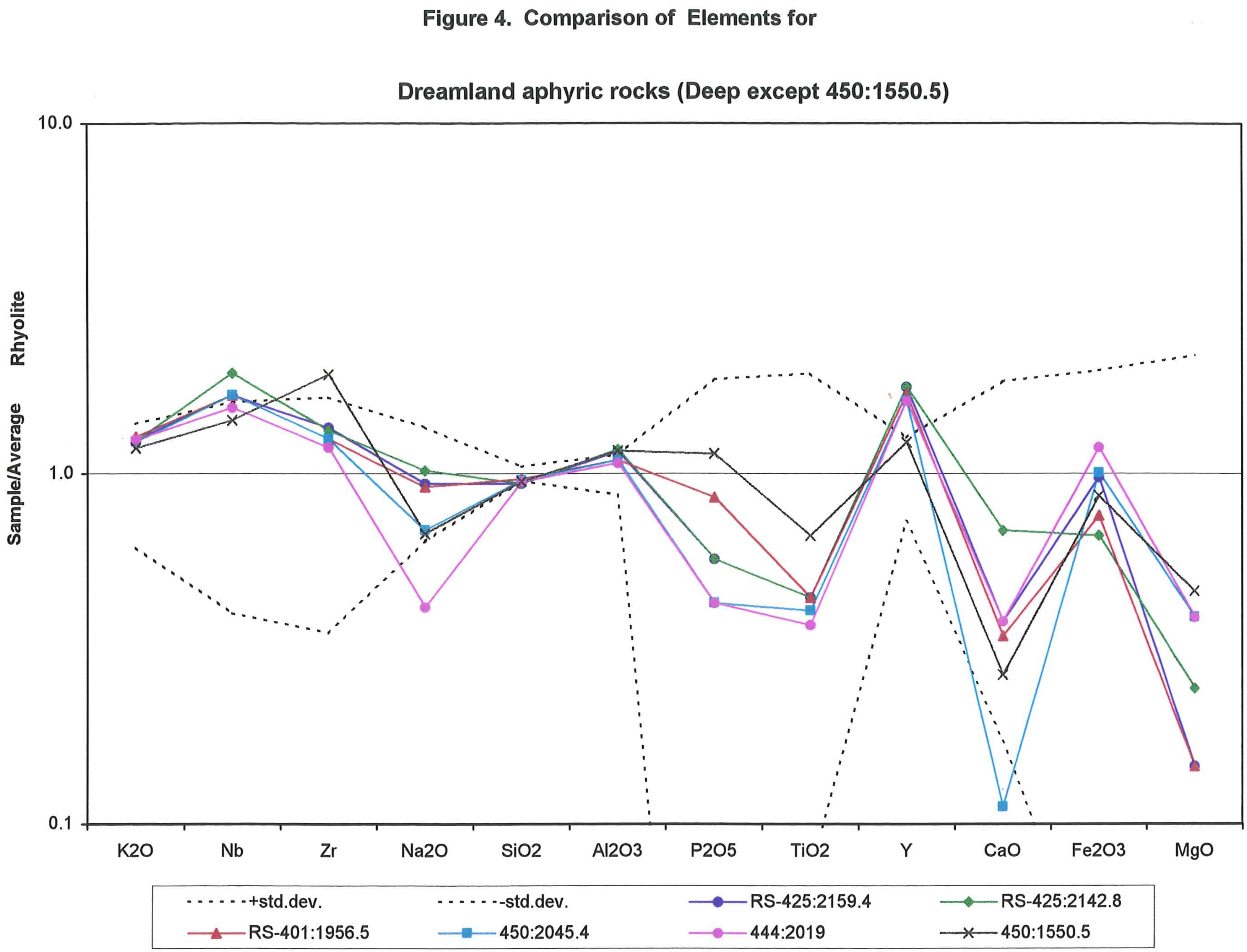
**Figure 3. Comparison of Elements for**

**"Dozer" aphyric rocks**




whmajor, Dozer

1/6/99

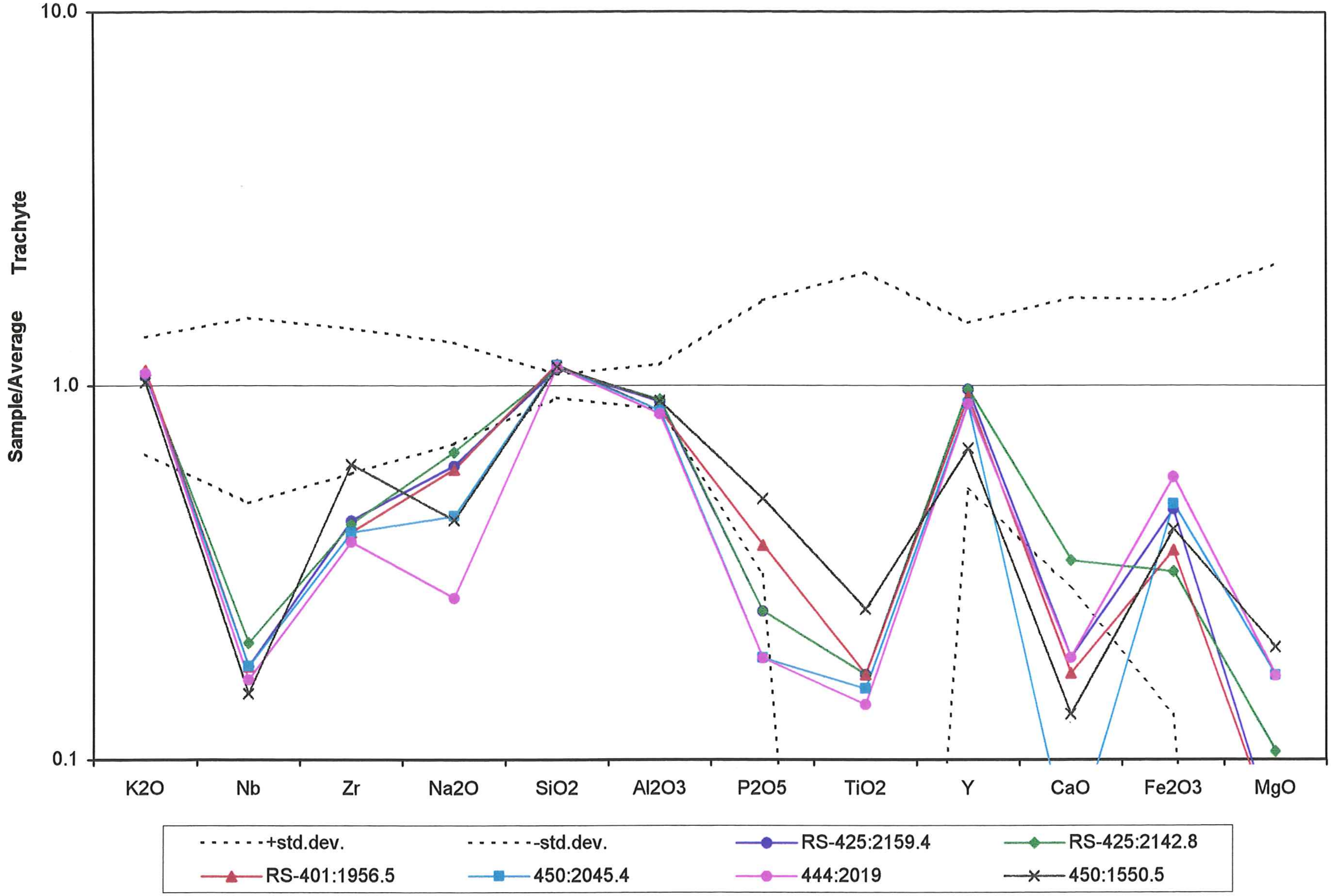



whmajor, Drmrhy

1/6/99

Figure 5. Comparison of Elements for

Dreamland aphyric rocks (Deep except 450:1550.5)




whmajor, Drmrhy

1/6/99

# Figure 6. Comparison of Elements for

# Sparsely feldspar-phyric rock

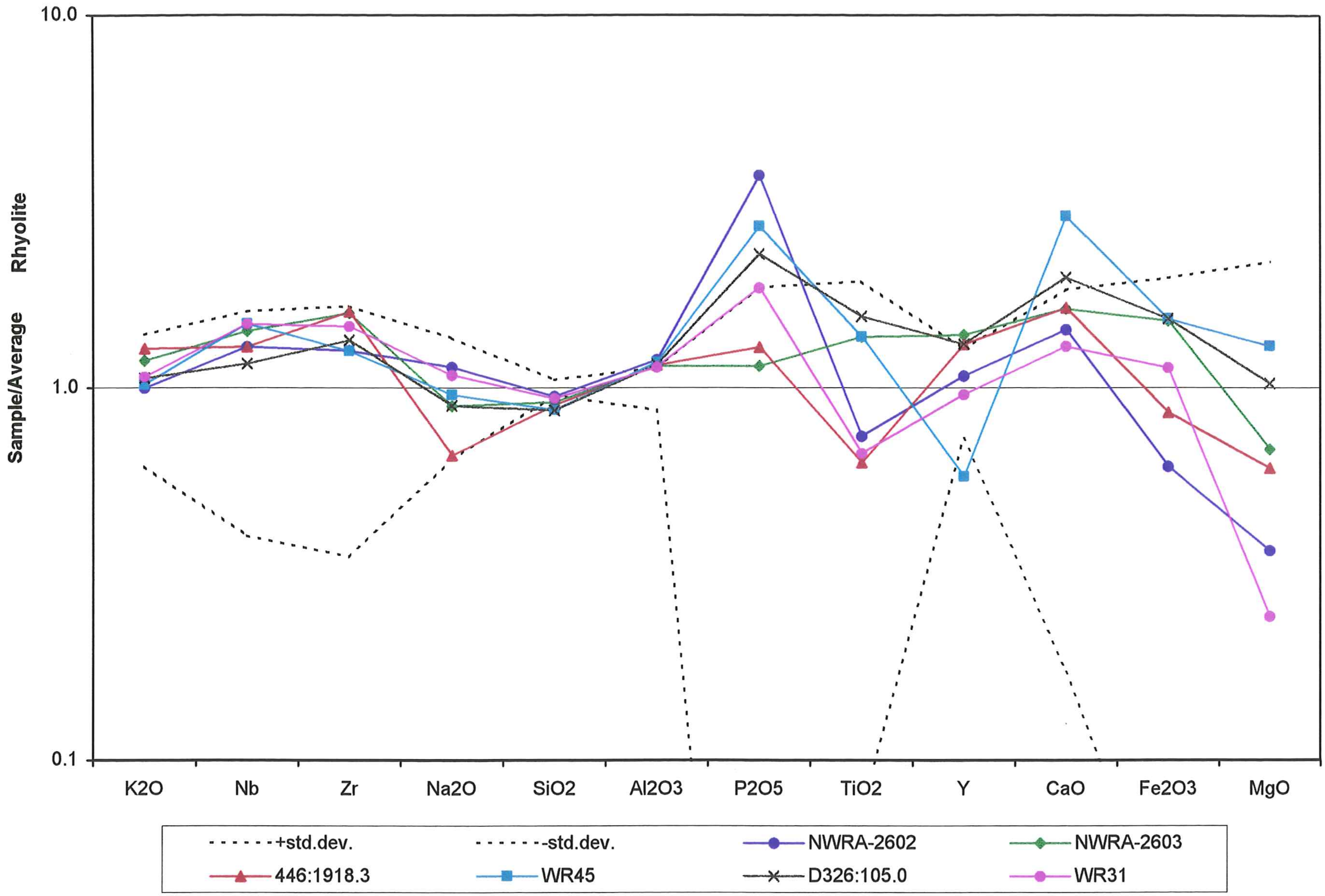


**Figure 7. Comparison of Elements for**

**Sparsely feldspar-phyric rock**

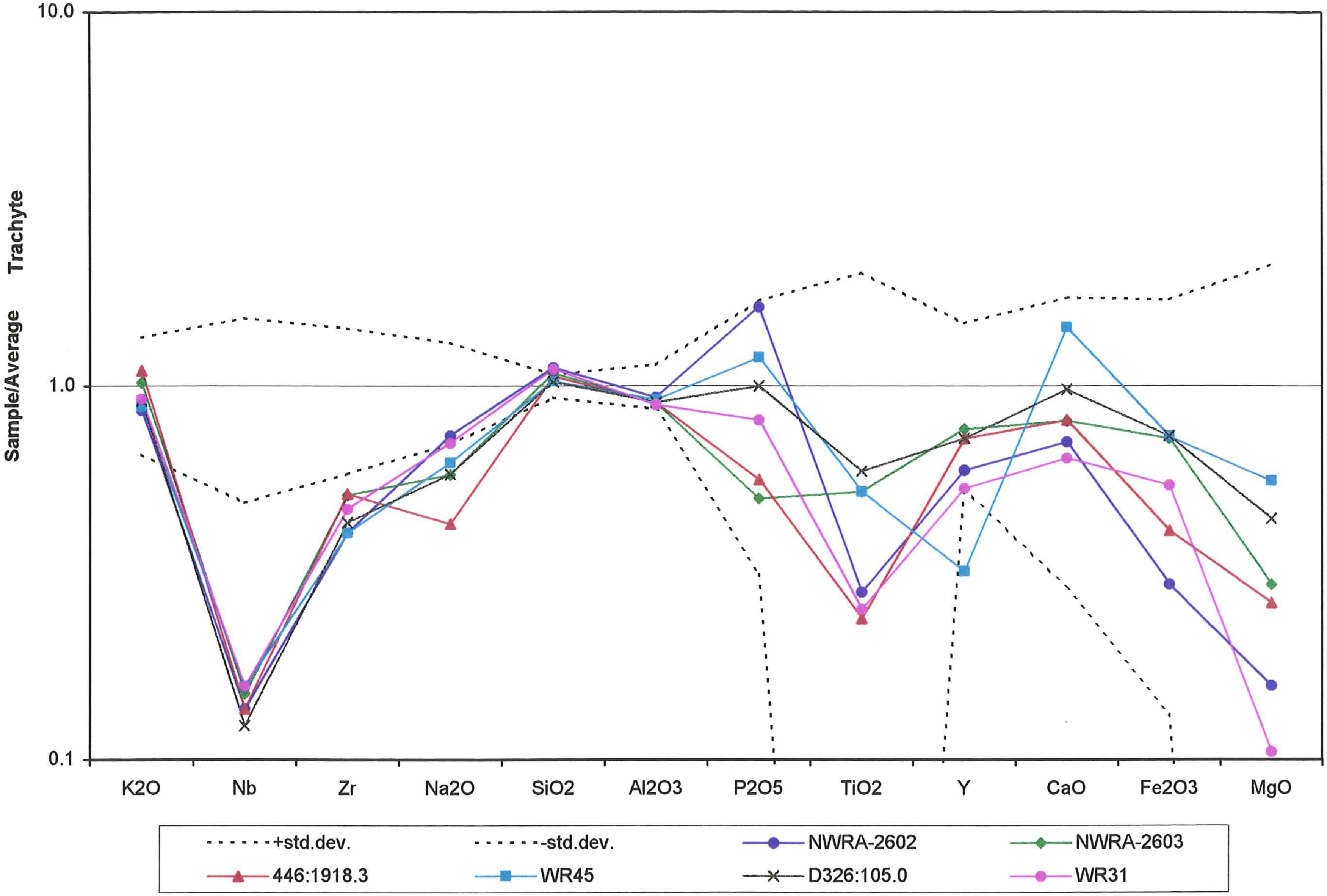
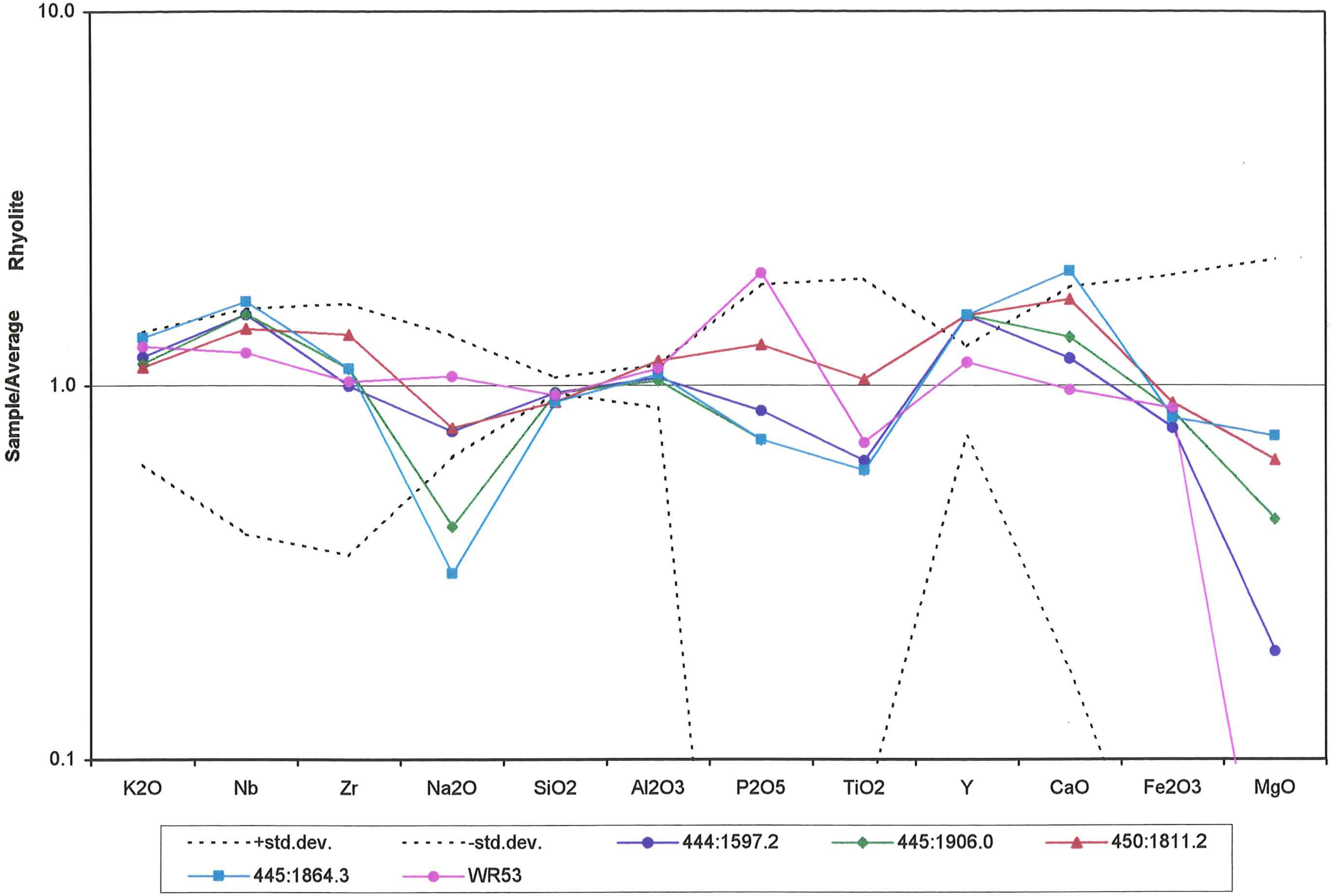


**Figure 8. Comparison of Elements for**

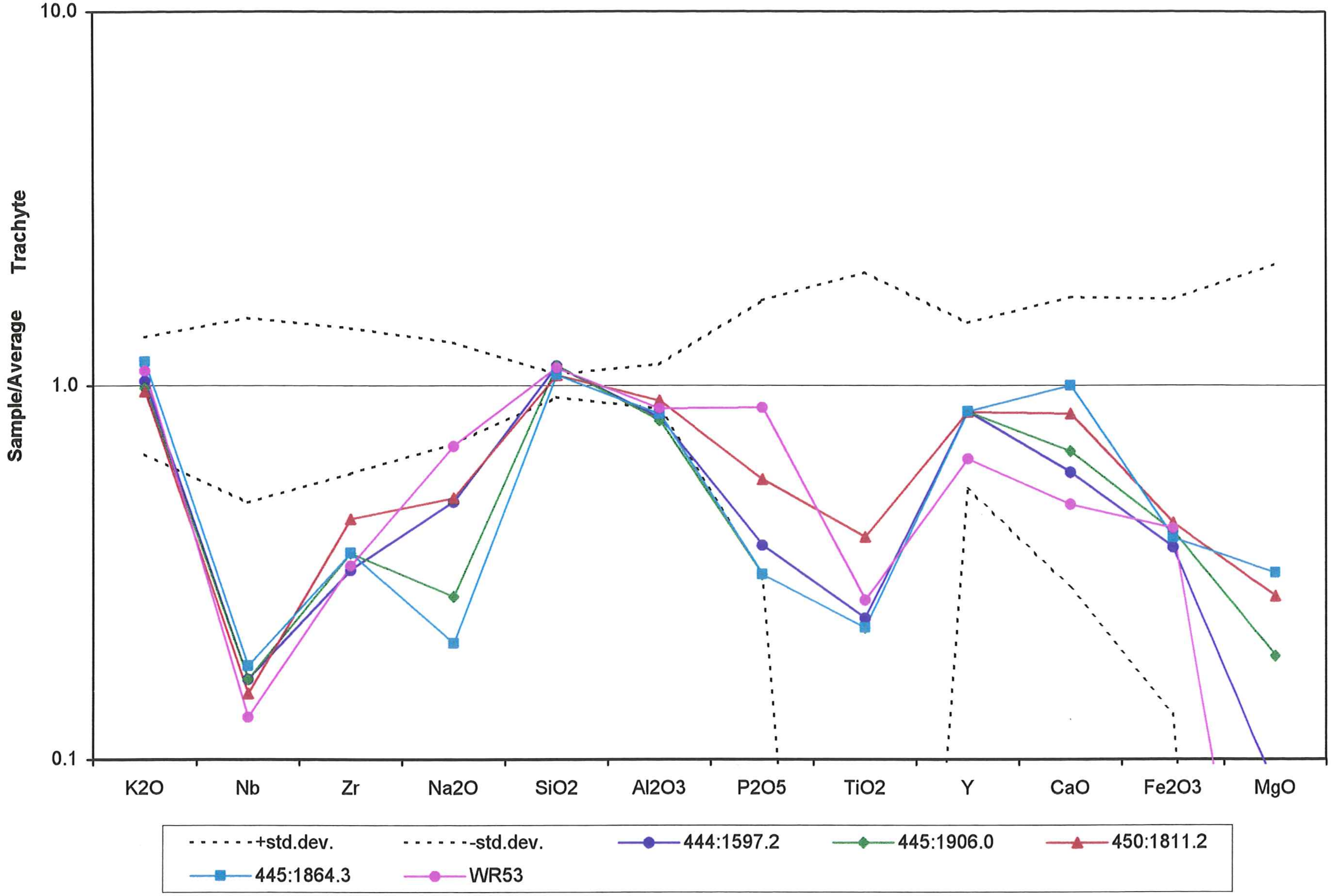
**Feldspar-phyric rocks with mmb (except WR53, 450:1811.2)**




whmajor, mmb 1/6/99

## Figure 9. Comparison of Elements for

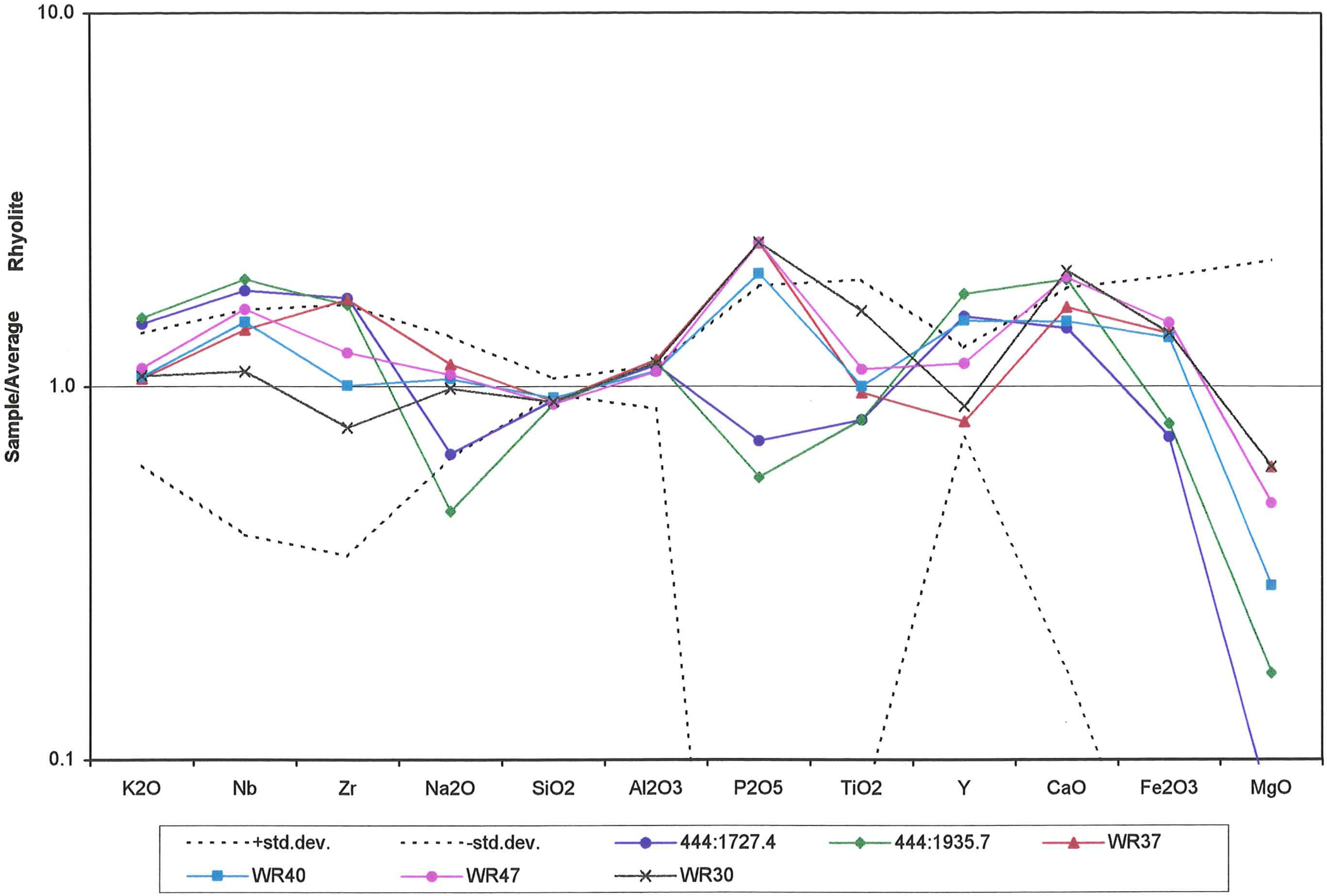
## Feldspar-phyric rocks with mmb (except WR53, 450:1811.2)




whmajor, mmb 1/6/99

**Figure 10. Comparison of Elements for**

**Porphyritic rocks, etc.**




whmajor, porrks 1/6/99

## Figure 11. Comparison of Elements for

## Porphyritic rocks, etc.

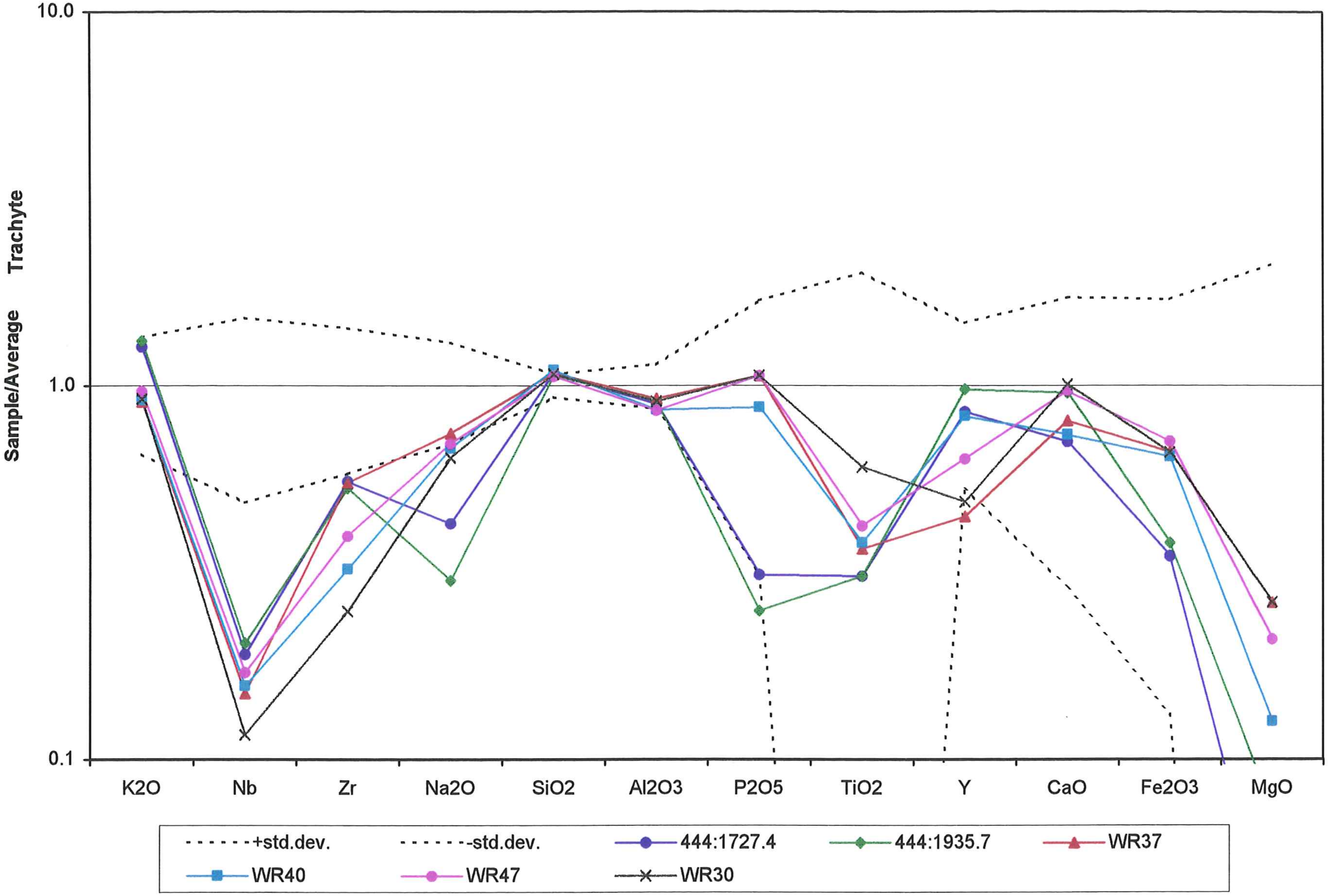
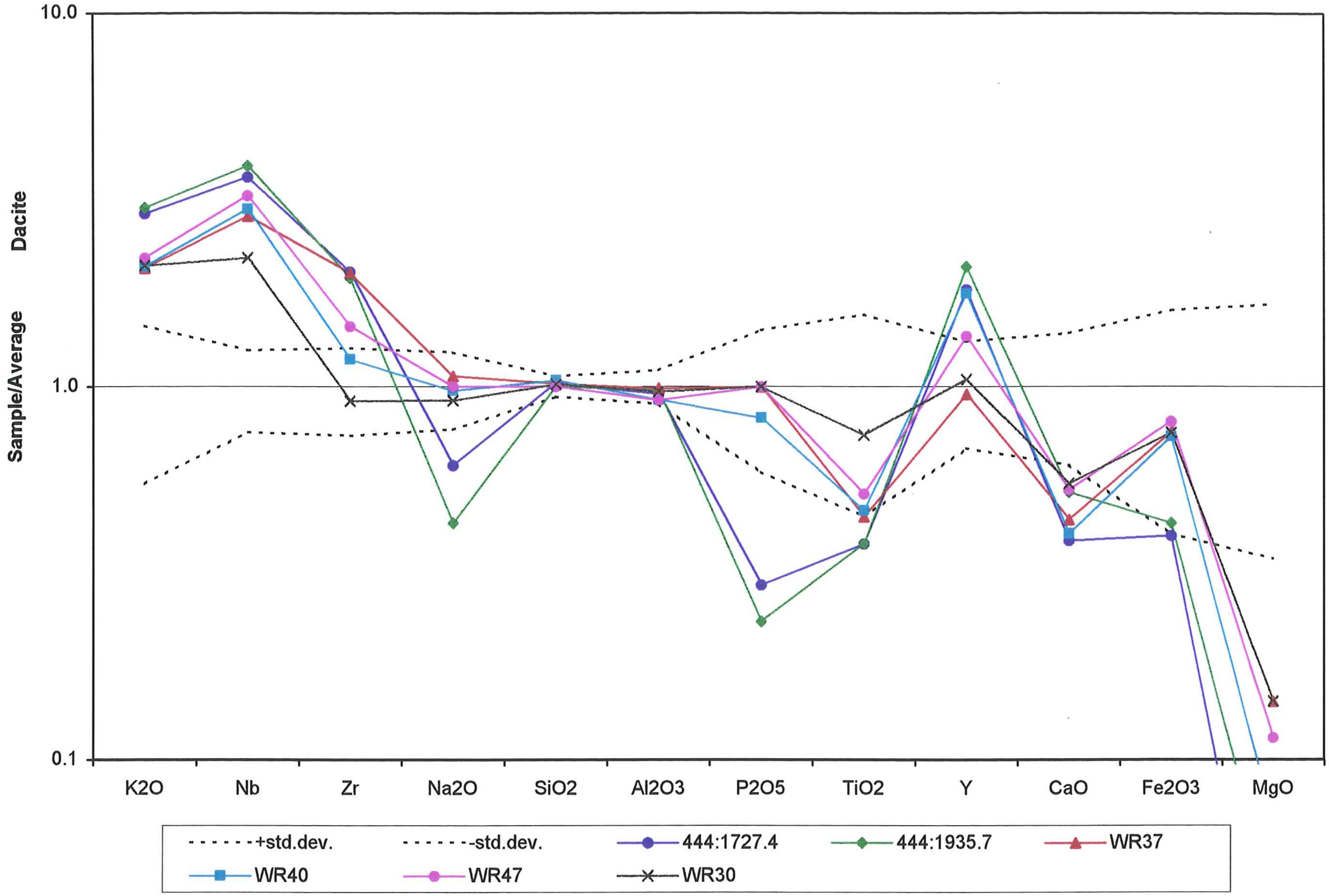


Figure 12. Comparison of Elements for

Porphyritic rocks, etc.

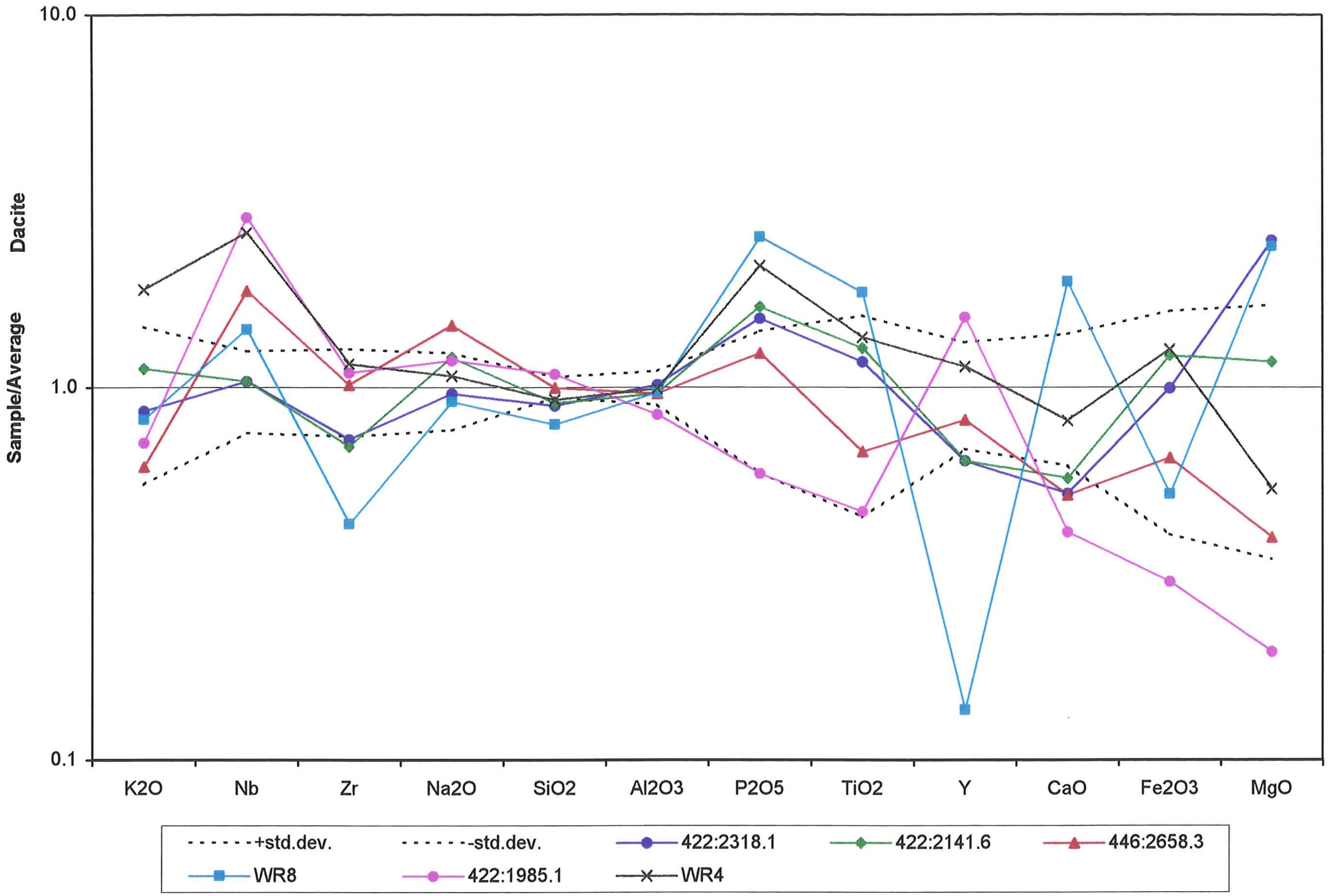



whmajor, porrks

1/6/99

## Figure 13. Comparison of Elements for

## "Intermediate" rocks




whmajor, intrks

1/6/99

**Figure 14. Comparison of Elements for**

**"Intermediate" rocks**

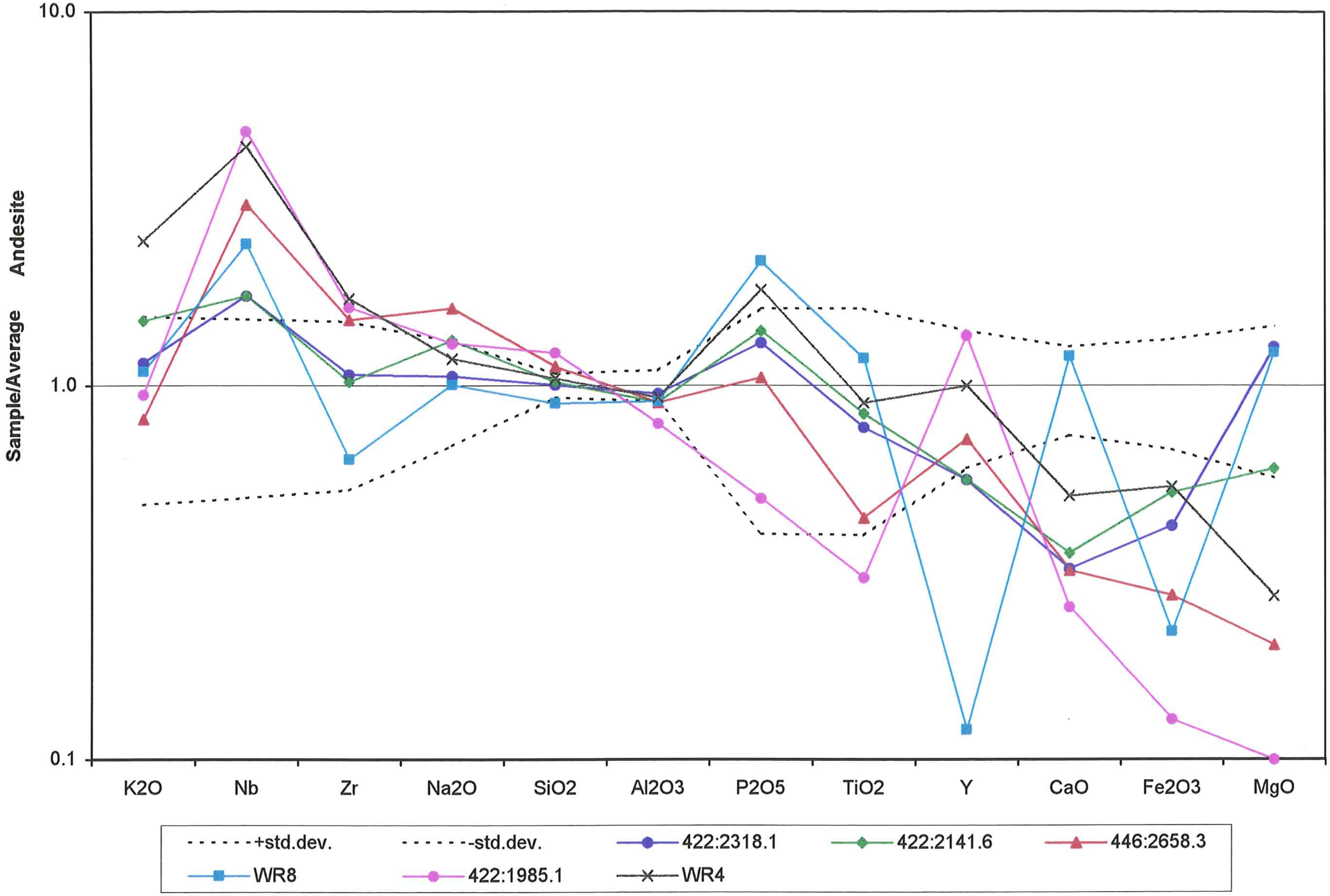
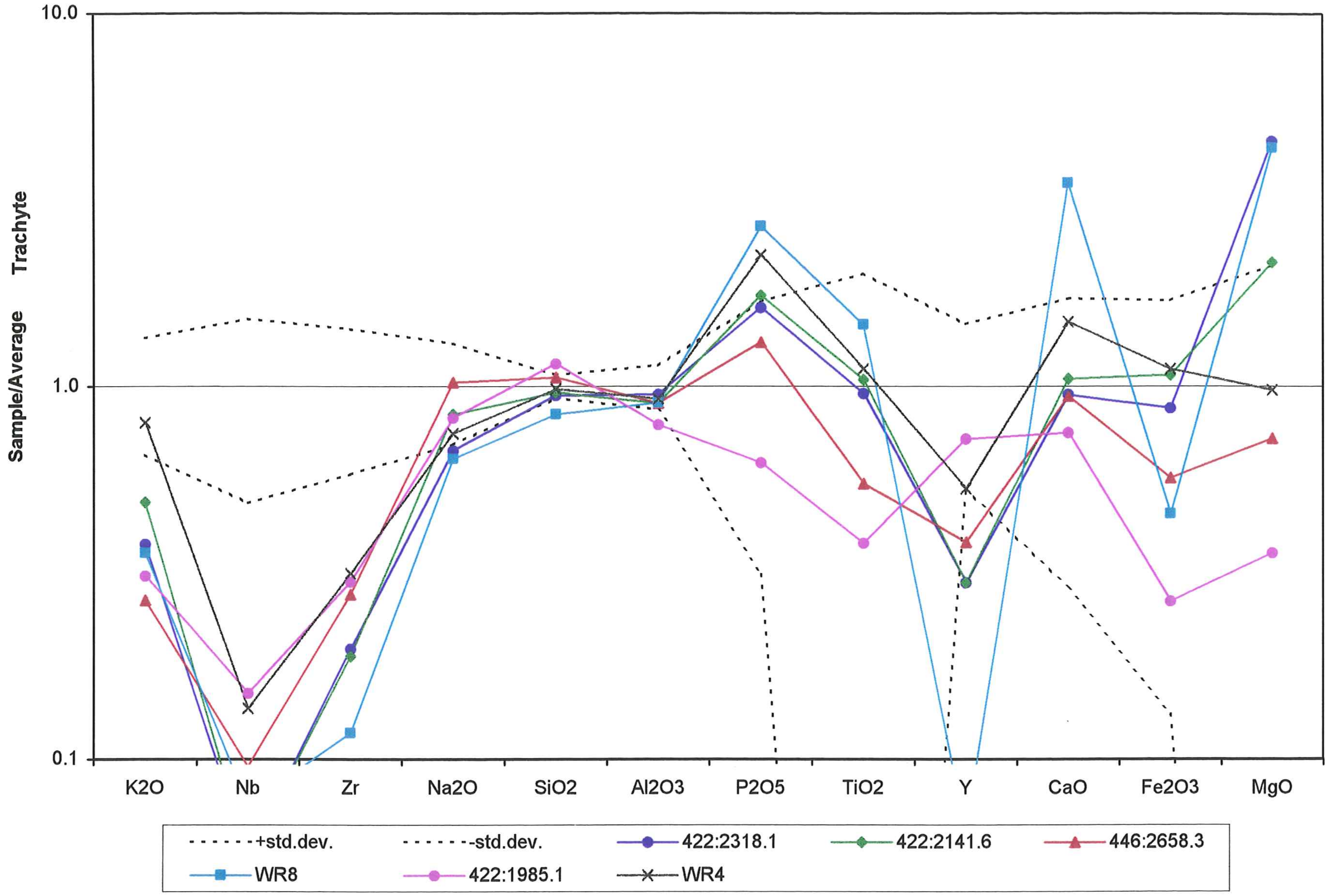


**Figure 15. Comparison of Elements for**

**"Intermediate" rocks**



| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **Table 1. Summary of Chemical Data for Rosebud Volcanic Rocks** | | | | | | | | | | | | | | | Alteration screen | | | | | | | | |
| Sample: | Al2O3 | CaO | Cr2O | Fe2O | K2O | MgO | MnO | Na2 | P2O5 | SiO2 | TiO2 | LOI | Sum | Ba | Rb | Sr | Nb | Zr | Y | Si/Al | A/CNK | Na/Ca | Rb/Sr | LOI | Na2O | CaO | MgO | Alt. |
| **"Dozer" aphyric rock** | | | | | | | | | | | | | | | | | **altered if:** | | | **>5.0** | **>1.2** | **<0.3** | **>2** | **>3.0** | **<0.5** | **<0.3** | **<.05** | |
| 410:943.5 | 16.22 | 2 | 0 | 1.28 | 4.36 | 0.21 | 0.16 | 4.32 | 0.12 | 67.31 | 0.35 | 2.82 | 99.15 | 705 | 140 | 182 | 22 | 267 | 42 | 4.1 | 1.05 | 2.2 | 0.8 | 2.8 | 4.3 | 2.0 | 0.21 | w |
| **410:1047.6** | **14.37** | **3.52** | **0** | **1.51** | **5.53** | **0.16** | **0.46** | **2.82** | **0.03** | **66.6** | **0.12** | **4.47** | **99.59** | **1025** | **168** | **212** | **22** | **285** | **40** | 4.6 | 0.84 | 0.8 | 0.8 | 4.5 | 2.8 | 3.5 | 0.16 | y |
| 454:169.0 | 14.68 | 1.16 | 0 | 2.92 | 5.53 | 0.11 | 0.03 | 2.46 | 0.04 | 69.2 | 0.12 | 2.71 | 98.96 | 605 | 198 | 94 | 24 | 276 | 42 | 4.7 | 1.21 | 2.1 | 2.1 | 2.7 | 2.5 | 1.2 | 0.11 | y |
| **454:197.3** | **14.81** | **0.93** | **0** | **3.04** | **5.01** | **0.1** | **0.03** | **2.79** | **0.03** | **70.05** | **0.12** | **2.36** | **99.27** | **550** | **186** | **88** | **24** | **276** | **42** | 4.7 | 1.27 | 3.0 | 2.1 | 2.4 | 2.8 | 0.9 | 0.10 | y |
| WR49 | 14.64 | 0.22 | 0 | 2.16 | 5.17 | 0.1 | 0.02 | 3.28 | 0.08 | 72.57 | 0.11 | 1.54 | 99.89 | 950 | 175 | 44 | 27 | 280 | 31 | 5.0 | 1.29 | 14.9 | 4.0 | 1.5 | 3.3 | 0.2 | 0.10 | y |
| WR20 | 13.78 | 0.67 | 0 | 1.75 | 5.27 | 0.27 | 0.04 | 2.9 | 0.08 | 72.35 | 0.08 | 2.68 | 99.87 | 180 | 210 | 28 | 30 | 225 | 28 | 5.3 | 1.18 | 4.3 | 7.5 | 2.7 | 2.9 | 0.7 | 0.27 | y |
| WR70 | 14.06 | 0.52 | 0 | 1.12 | 6.12 | 0.09 | 0.01 | 1.77 | 0.07 | 72.41 | 0.09 | 3.2 | 99.46 | 430 | 225 | 55 | 27 | 205 | 39 | 5.2 | 1.34 | 3.4 | 4.1 | 3.2 | 1.8 | 0.5 | 0.09 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Deep Dreamland aphyric rock** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **425:2159.4** | **15.68** | **0.44** | **0** | **2.7** | **5.47** | **0.06** | **0.03** | **3.4** | **0.04** | **69.55** | **0.12** | **1.48** | **98.97** | **650** | **198** | **104** | **26** | **297** | **46** | 4.4 | 1.27 | 7.7 | 1.9 | 1.5 | 3.4 | 0.4 | 0.06 | y |
| 425:2142.8 | 15.85 | 0.8 | 0 | 1.84 | 5.43 | 0.1 | 0.04 | 3.7 | 0.04 | 69.57 | 0.12 | 1.79 | 99.28 | 550 | 184 | 118 | 30 | 291 | 46 | 4.4 | 1.18 | 4.6 | 1.6 | 1.8 | 3.7 | 0.8 | 0.10 | |
| 444:2046.4 | 14.48 | 1.2 | 0 | 3.01 | 5.18 | 0.16 | 0.24 | 2.27 | 0.04 | 69.74 | 0.11 | 2.92 | 99.35 | 565 | 194 | 166 | 26 | 270 | 42 | 4.8 | 1.26 | 1.9 | 1.2 | 2.9 | 2.3 | 1.2 | 0.16 | y |
| 401:1956.5 | 14.82 | 0.4 | 0 | 2.1 | 5.59 | 0.06 | 0.04 | 3.33 | 0.06 | 71.55 | 0.12 | 1.12 | 99.19 | 580 | 198 | 102 | 26 | 276 | 44 | 4.8 | 1.21 | 8.3 | 1.9 | 1.1 | 3.3 | 0.4 | 0.06 | y |
| 450:2045.4 | 14.8 | 0.13 | 0 | 2.78 | 5.41 | 0.16 | 0.08 | 2.5 | 0.03 | 70.93 | 0.11 | 2.29 | 99.22 | 470 | 190 | 134 | 26 | 276 | 42 | 4.8 | 1.45 | 19.2 | 1.4 | 2.3 | 2.5 | 0.1 | 0.16 | y |
| 444:2019 | 14.55 | 0.44 | 0 | 3.29 | 5.49 | 0.16 | 0.03 | 1.51 | 0.03 | 70.31 | 0.1 | 2.76 | 98.67 | 560 | 198 | 228 | 24 | 261 | 42 | 4.8 | 1.58 | 3.4 | 0.9 | 2.8 | 1.5 | 0.4 | 0.16 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Shallow Dreamland aphyric rock** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 450:1512.1 | 14.96 | 2.34 | 0 | 3.01 | 4.23 | 0.15 | 0.16 | 3.46 | 0.09 | 66.56 | 0.17 | 3.48 | 98.61 | 930 | 148 | 196 | 20 | 393 | 34 | 4.4 | 1.03 | 1.5 | 0.8 | 3.5 | 3.5 | 2.3 | 0.15 | y |
| 426:1361.2 | 15.19 | 0.34 | 0 | 2.66 | 5.72 | 0.05 | 0.02 | 3.46 | 0.05 | 70.88 | 0.11 | 1.13 | 99.61 | 480 | 192 | 90 | 26 | 276 | 44 | 4.7 | 1.22 | 10.2 | 2.1 | 1.1 | 3.5 | 0.3 | 0.05 | y |
| 450:1550.5 | 15.71 | 0.31 | 0 | 2.39 | 5.19 | 0.19 | 0.04 | 2.44 | 0.08 | 70.33 | 0.18 | 2.44 | 99.3 | 1130 | 188 | 210 | 22 | 420 | 32 | 4.5 | 1.54 | 7.9 | 0.9 | 2.4 | 2.4 | 0.3 | 0.19 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Aphyric rocks with mmb** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **443:1796.2** | **15.49** | **1.18** | **0** | **3.71** | **4.94** | **0.21** | **0.06** | **3.41** | **0.08** | **66.28** | **0.3** | **2.89** | **98.55** | **735** | **162** | **218** | **24** | **312** | **40** | 4.3 | 1.18 | 2.9 | 0.7 | 2.9 | 3.4 | 1.2 | 0.21 | tr |
| 450:1811.2 | 15.74 | 1.97 | 0 | 2.48 | 4.9 | 0.26 | 0.12 | 2.79 | 0.09 | 66.82 | 0.28 | 3.59 | 99.04 | 775 | 182 | 202 | 22 | 300 | 40 | 4.2 | 1.17 | 1.4 | 0.9 | 3.6 | 2.8 | 2.0 | 0.26 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Sparsely feldspar-phyric rocks (=LBT, Wildrose, brown flow, Brady andesite)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WR12 | 16.4 | 3.27 | 0 | 5.25 | 3.68 | 1.11 | 0.09 | 4.05 | 0.27 | 62.95 | 0.61 | 2.15 | 99.83 | 1100 | 130 | 305 | 20 | 255 | 13 | 3.8 | 0.99 | 1.2 | 0.4 | 2.2 | 4.1 | 3.3 | 1.11 | |
| WR36 | 16.51 | 3.24 | 0 | 5.16 | 3.78 | 1.11 | 0.07 | 3.79 | 0.25 | 62.93 | 0.6 | 1.95 | 99.39 | 1100 | 140 | 305 | 21 | 260 | 21 | 3.8 | 1.02 | 1.2 | 0.5 | 2.0 | 3.8 | 3.2 | 1.11 | |
| WR6 | 16.6 | 3.32 | 0 | 1.93 | 3.19 | 1.14 | 0.11 | 4.53 | 0.31 | 62.53 | 0.7 | 1.37 | 95.73 | 1200 | 120 | 325 | 26 | 285 | 22 | 3.8 | 0.98 | 1.4 | 0.4 | 1.4 | 4.5 | 3.3 | 1.14 | |
| WR45 | 15.85 | 3.35 | 0 | 4.22 | 4.47 | 0.53 | 0.12 | 3.47 | 0.19 | 64.5 | 0.37 | 2.33 | 99.4 | 1300 | 155 | 275 | 23 | 275 | 15 | 4.1 | 0.95 | 1.0 | 0.6 | 2.3 | 3.5 | 3.4 | 0.53 | |
| WR13 | 16.44 | 2.15 | 0 | 3.65 | 4.42 | 0.48 | 0.08 | 4.04 | 0.2 | 65.62 | 0.32 | 2.11 | 99.51 | 1200 | 155 | 255 | 22 | 300 | 21 | 4.0 | 1.07 | 1.9 | 0.6 | 2.1 | 4.0 | 2.2 | 0.48 | |
| D326:105.0 | 15.61 | 2.29 | 0 | 4.23 | 4.64 | 0.42 | 0.07 | 3.24 | 0.16 | 64.25 | 0.42 | 3.7 | 99.03 | 1330 | 172 | 260 | 18 | 294 | 34 | 4.1 | 1.08 | 1.4 | 0.7 | 3.7 | 3.2 | 2.3 | 0.42 | y |
| WR34 | 16.12 | 2.41 | 0 | 4.07 | 4.21 | 0.32 | 0.07 | 4.25 | 0.2 | 66.29 | 0.36 | 1.47 | 99.77 | 1200 | 150 | 250 | 20 | 285 | 19 | 4.1 | 1.01 | 1.8 | 0.6 | 1.5 | 4.3 | 2.4 | 0.32 | |
| WR17 | 15.5 | 2.54 | 0 | 4.69 | 4.27 | 0.48 | 0.06 | 3.3 | 0.4 | 65.67 | 0.47 | 2.35 | 99.73 | 1100 | 147 | 240 | 21 | 255 | 19 | 4.2 | 1.06 | 1.3 | 0.6 | 2.4 | 3.3 | 2.5 | 0.48 | |
| WR10 | 15.93 | 2.34 | 0 | 4.42 | 4.08 | 0.55 | 0.05 | 3.77 | 0.21 | 66.08 | 0.38 | 1.87 | 99.68 | 1200 | 135 | 245 | 19 | 280 | 24 | 4.1 | 1.07 | 1.6 | 0.6 | 1.9 | 3.8 | 2.3 | 0.55 | |
| WR11 | 16.08 | 2.25 | 0 | 3.96 | 4.13 | 0.37 | 0.05 | 3.54 | 0.22 | 66.51 | 0.4 | 1.91 | 99.42 | 1200 | 145 | 235 | 26 | 285 | 19 | 4.1 | 1.12 | 1.6 | 0.6 | 1.9 | 3.5 | 2.3 | 0.37 | |
| **NWRA-2603** | **15.49** | **1.89** | **0** | **4.17** | **5.18** | **0.28** | **0.07** | **3.23** | **0.26** | **67.77** | **0.37** | **1.13** | **99.84** | **1155** | **158** | **214** | **20** | **276** | **28** | 4.4 | 1.08 | 1.7 | 0.7 | 1.1 | 3.2 | 1.9 | 0.28 | tr.chalcedon |
| WR18 | 16.21 | 2.45 | 0 | 1.77 | 4.31 | 0.4 | 0.08 | 3.43 | 0.21 | 65.35 | 0.34 | 2.48 | 97.03 | 1200 | 145 | 225 | 24 | 300 | 18 | 4.0 | 1.10 | 1.4 | 0.6 | 2.5 | 3.4 | 2.5 | 0.40 | |
| WR35 | 16.29 | 2.24 | 0 | 2.56 | 4.3 | 0.27 | 0.03 | 4.07 | 0.19 | 67.87 | 0.31 | 1.77 | 99.9 | 1200 | 155 | 255 | 21 | 305 | 21 | 4.2 | 1.06 | 1.8 | 0.6 | 1.8 | 4.1 | 2.2 | 0.27 | |
| WR7 | 15.73 | 1.7 | 0 | 3.67 | 4.42 | 0.08 | 0.08 | 4.22 | 0.13 | 67.95 | 0.19 | 1.15 | 99.32 | 1100 | 160 | 215 | 28 | 330 | 15 | 4.3 | 1.06 | 2.5 | 0.7 | 1.2 | 4.2 | 1.7 | 0.08 | |
| WR16 | 16.42 | 1.95 | 0 | 1.8 | 4.53 | 0.54 | 0.05 | 3.91 | 0.19 | 67.39 | 0.31 | 2.67 | 99.76 | 1200 | 150 | 245 | 22 | 305 | 24 | 4.1 | 1.10 | 2.0 | 0.6 | 2.7 | 3.9 | 2.0 | 0.54 | |
| WR14 | 15.17 | 1.43 | 0 | 3.99 | 5 | 0.34 | 0.02 | 3.16 | 0.19 | 68.22 | 0.26 | 2.07 | 99.85 | 1100 | 190 | 180 | 20 | 285 | 26 | 4.5 | 1.15 | 2.2 | 1.1 | 2.1 | 3.2 | 1.4 | 0.34 | |
| WR71 | 16.1 | 1.65 | 0 | 2.62 | 4.67 | 0.03 | 0.03 | 3.98 | 0.14 | 68.85 | 0.18 | 1.24 | 99.49 | 1100 | 170 | 175 | 18 | 265 | 3 | 4.3 | 1.10 | 2.4 | 1.0 | 1.2 | 4.0 | 1.7 | 0.03 | y |
| 446:1918.3 | 15.56 | 1.9 | 0 | 2.37 | 5.58 | 0.25 | 0.05 | 2.39 | 0.09 | 66.55 | 0.17 | 3.79 | 98.7 | 1600 | 222 | 228 | 20 | 351 | 34 | 4.3 | 1.16 | 1.3 | 1.0 | 3.8 | 2.4 | 1.9 | 0.25 | y |

| | | | | | Table 1. Summary of Chemical Data for Rosebud Volcanic Rocks | | | | | | | | | | | | | | | Alteration screen | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample: | Al2O3 | CaO | Cr2O | Fe2O | K2O | MgO | MnO | Na2 | P2O5 | SiO2 | TiO2 | LOI | Sum | Ba | Rb | Sr | Nb | Zr | Y | Si/Al | A/CNK | Na/Ca | Rb/Sr | LOI | Na2O | CaO | MgO | Alt. |
| **WR31** | **15.37** | **1.5** | **0** | **3.13** | **4.69** | **0.1** | **0.12** | **3.92** | **0.13** | **69.42** | **0.18** | **1.32** | **99.88** | **1100** | **165** | **180** | **23** | **320** | **25** | 4.5 | 1.08 | 2.6 | 0.9 | 1.3 | 3.9 | 1.5 | 0.10 | |
| NWRA-2601 | 16.08 | 1.74 | 0 | 1.44 | 4.76 | 0.16 | 0.02 | 3.77 | 0.13 | 69.72 | 0.19 | 1.83 | 99.84 | 1040 | 174 | 190 | 24 | 348 | 42 | 4.3 | 1.11 | 2.2 | 0.9 | 1.8 | 3.8 | 1.7 | 0.16 | tr |
| 446:1907.2 | 15.53 | 1.97 | 0 | 1.97 | 6.68 | 0.25 | 0.13 | 0.6 | 0.08 | 67.53 | 0.18 | 4.35 | 99.27 | 1860 | 248 | 102 | 20 | 342 | 36 | 4.3 | 1.32 | 0.3 | 2.4 | 4.4 | 0.6 | 2.0 | 0.25 | y |
| **NWRA-2602** | **16.07** | **1.66** | **0** | **1.7** | **4.38** | **0.15** | **0.01** | **4.11** | **0.08** | **70.19** | **0.2** | **1.23** | **99.78** | **1035** | **168** | **196** | **22** | **348** | **36** | 4.4 | 1.11 | 2.5 | 0.9 | 1.2 | 4.1 | 1.7 | 0.15 | |
| WR161 | 14.89 | 0.93 | 0 | 3.08 | 4.17 | 0.37 | 0.14 | 3.98 | 0.18 | 69.57 | 0.25 | 2.53 | 100.1 | 1100 | 115 | 135 | 23 | 290 | 17 | 4.7 | 1.17 | 4.3 | 0.9 | 2.5 | 4.0 | 0.9 | 0.37 | |
| 446:1901.8 | 16.42 | 0.37 | 0 | 1.86 | 3.8 | 0.16 | 0.03 | 0.01 | 0.06 | 71.22 | 0.2 | 5.07 | 99.2 | 260 | 184 | 24 | 26 | 393 | 34 | 4.3 | 3.43 | 0.0 | 7.7 | 5.1 | 0.0 | 0.4 | 0.16 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **"Chocolate"** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WR5 | 15.6 | 1.93 | 0 | 3.87 | 4.79 | 0.15 | 0.05 | 3.51 | 0.17 | 66.66 | 0.28 | 2.41 | 99.42 | 1100 | 175 | 165 | 19 | 290 | 24 | 4.3 | 1.08 | 1.8 | 1.1 | 2.4 | 3.5 | 1.9 | 0.15 | |
| WR15 | 15.43 | 1.36 | 0 | 3.93 | 6.24 | 0.31 | 0.11 | 2.26 | 0.16 | 66.75 | 0.26 | 2.84 | 99.65 | 1300 | 210 | 130 | 21 | 285 | 29 | 4.3 | 1.19 | 1.7 | 1.6 | 2.8 | 2.3 | 1.4 | 0.31 | |
| WR74 | 15.89 | 1.44 | 0 | 3.12 | 5 | 0.19 | 0.09 | 3.44 | 0.16 | 67.55 | 0.2 | 2.64 | 99.72 | 1400 | 180 | 170 | 16 | 270 | 3 | 4.3 | 1.16 | 2.4 | 1.1 | 2.6 | 3.4 | 1.4 | 0.19 | |
| WR55 | 15.27 | 1.52 | 0 | 3.03 | 5.17 | 0.1 | 0.1 | 3.35 | 0.16 | 68.12 | 0.21 | 2.62 | 99.65 | 1400 | 170 | 170 | 24 | 355 | 21 | 4.5 | 1.10 | 2.2 | 1.0 | 2.6 | 3.4 | 1.5 | 0.10 | |
| WR72 | 15.54 | 1.59 | 0 | 3.01 | 4.54 | 0.14 | 0.03 | 3.92 | 0.13 | 69.14 | 0.17 | 1.38 | 99.59 | 1000 | 155 | 165 | 16 | 255 | 3 | 4.4 | 1.09 | 2.5 | 0.9 | 1.4 | 3.9 | 1.6 | 0.14 | |
| WR50 | 15.21 | 1.01 | 0 | 3.52 | 5.27 | 0.1 | 0.01 | 3.23 | 0.12 | 69.44 | 0.22 | 1.95 | 100.1 | 750 | 230 | 78 | 25 | 295 | 47 | 4.6 | 1.18 | 3.2 | 2.9 | 2.0 | 3.2 | 1.0 | 0.10 | y |
| **WR53** | **15.01** | **1.13** | **0** | **2.4** | **5.57** | **0.01** | **0.03** | **3.84** | **0.14** | **69.82** | **0.19** | **1.32** | **99.46** | **1200** | **190** | **115** | **19** | **225** | **30** | 4.7 | 1.04 | 3.4 | 1.7 | 1.3 | 3.8 | 1.1 | 0.01 | y |
| WR39 | 14.78 | 2.43 | 0 | 1.97 | 4.63 | 0.1 | 0.03 | 3.53 | 0.19 | 69.39 | 0.38 | 2.09 | 99.52 | 890 | 180 | 140 | 22 | 215 | 34 | 4.7 | 0.97 | 1.5 | 1.3 | 2.1 | 3.5 | 2.4 | 0.10 | |
| WR51 | 14.23 | 0.38 | 0 | 3.28 | 5.65 | 0.1 | 0.05 | 1.17 | 0.13 | 71.89 | 0.25 | 2.61 | 99.74 | 710 | 225 | 31 | 25 | 210 | 32 | 5.1 | 1.63 | 3.1 | 7.3 | 2.6 | 1.2 | 0.4 | 0.10 | y |
| WR3 | 14.03 | 0.25 | 0 | 0.96 | 4.61 | 0.32 | 0.01 | 0.19 | 0.07 | 74.83 | 0.31 | 3.95 | 99.53 | 1100 | 225 | 39 | 29 | 240 | 18 | 5.3 | 2.44 | 0.8 | 5.8 | 4.0 | 0.2 | 0.3 | 0.32 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Feldspar-phyric rocks with mmb and locally rare quartz phenocrysts** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 443:1564.0 | 14.86 | 1.86 | 0 | 3.41 | 4.71 | 0.28 | 0.08 | 2.22 | 0.04 | 67.57 | 0.17 | 4.09 | 99.29 | 1030 | 194 | 216 | 20 | 384 | 30 | 4.5 | 1.22 | 1.2 | 0.9 | 4.1 | 2.2 | 1.9 | 0.28 | y |
| 445:1864.3 | 14.48 | 2.34 | 0 | 2.26 | 5.88 | 0.3 | 0.06 | 1.14 | 0.05 | 66.91 | 0.16 | 4.95 | 98.53 | 670 | 218 | 188 | 26 | 243 | 40 | 4.6 | 1.16 | 0.5 | 1.2 | 5.0 | 1.1 | 2.3 | 0.30 | y |
| **444:1597.2** | **14.19** | **1.37** | **0** | **2.13** | **5.22** | **0.08** | **0.06** | **2.73** | **0.06** | **70.78** | **0.17** | **2.54** | **99.33** | **635** | **212** | **174** | **24** | **219** | **40** | 5.0 | 1.12 | 2.0 | 1.2 | 2.5 | 2.7 | 1.4 | 0.08 | tr |
| 445:1906.0 | 13.94 | 1.56 | 0 | 2.35 | 5.01 | 0.18 | 0.05 | 1.52 | 0.05 | 70.66 | 0.16 | 3.61 | 99.09 | 580 | 212 | 126 | 24 | 243 | 40 | 5.1 | 1.30 | 1.0 | 1.7 | 3.6 | 1.5 | 1.6 | 0.18 | y |
| 445:1853.4 | 15.18 | 1.15 | 0 | 2.22 | 5.2 | 0.12 | 0.05 | 0.12 | 0.04 | 69.9 | 0.18 | 4.78 | 98.94 | 1705 | 208 | 84 | 26 | 258 | 44 | 4.6 | 1.92 | 0.1 | 2.5 | 4.8 | 0.1 | 1.2 | 0.12 | y |
| 445:1777.0 | 16.76 | 0.25 | 0.00 | 2.49 | 2.69 | 0.18 | 0.02 | 0.01 | 0.06 | 70.67 | 0.21 | 5.84 | 99.18 | 60 | 156 | 44 | 32 | 327 | 58 | 4.2 | 4.95 | 0.0 | 3.5 | 5.8 | 0.0 | 0.3 | 0.18 | y |
| 445:1793.6 | 15.21 | 0.24 | 0 | 1.59 | 4.16 | 0.13 | 0.01 | 0.01 | 0.05 | 73.08 | 0.19 | 4.37 | 99.04 | 485 | 184 | 42 | 30 | 312 | 52 | 4.8 | 3.07 | 0.0 | 4.4 | 4.4 | 0.0 | 0.2 | 0.13 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Porphyritic "Chocolate" or "intrusions"** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WR4 | 15.98 | 3.49 | 0 | 6.4 | 4.06 | 0.93 | 0.09 | 4.17 | 0.36 | 61.5 | 0.79 | 1.93 | 99.7 | 910 | 165 | 275 | 20 | 215 | 25 | 3.8 | 0.91 | 1.2 | 0.6 | 1.9 | 4.2 | 3.5 | 0.93 | |
| WR61 | 15.89 | 3.05 | 0 | 6.52 | 4.21 | 0.9 | 0.06 | 3.63 | 0.34 | 61.69 | 0.75 | 2.27 | 99.31 | 1000 | 160 | 240 | 26 | 245 | 33 | 3.9 | 0.99 | 1.2 | 0.7 | 2.3 | 3.6 | 3.1 | 0.90 | |
| WR21 | 16.17 | 1.88 | 0 | 6.26 | 4.96 | 0.34 | 0.04 | 3.49 | 0.33 | 63.41 | 0.71 | 2.28 | 99.87 | 1100 | 205 | 170 | 29 | 275 | 42 | 3.9 | 1.11 | 1.9 | 1.2 | 2.3 | 3.5 | 1.9 | 0.34 | |
| WR47 | 14.82 | 2.27 | 0 | 4.09 | 4.9 | 0.2 | 0.08 | 3.9 | 0.17 | 66.47 | 0.3 | 2.49 | 99.69 | 960 | 195 | 150 | 25 | 270 | 30 | 4.5 | 0.94 | 1.7 | 1.3 | 2.5 | 3.9 | 2.3 | 0.20 | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **West Kamma Peak intrusions** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WR38 | 16.6 | 2.69 | 0 | 4.44 | 4.05 | 0.58 | 0.16 | 4.16 | 0.22 | 65.03 | 0.41 | 1.19 | 99.53 | 1200 | 135 | 280 | 23 | 330 | 19 | 3.9 | 1.03 | 1.5 | 0.5 | 1.2 | 4.2 | 2.7 | 0.58 | |
| WR37 | 15.93 | 1.89 | 0 | 3.83 | 4.6 | 0.25 | 0.08 | 4.15 | 0.17 | 67.68 | 0.26 | 0.94 | 99.78 | 1300 | 150 | 225 | 22 | 375 | 21 | 4.2 | 1.05 | 2.2 | 0.7 | 0.9 | 4.2 | 1.9 | 0.25 | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Lantern intrusions** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **WR40** | **14.86** | **1.73** | **0.00** | **3.72** | **4.65** | **0.12** | **0.02** | **3.79** | **0.14** | **68.92** | **0.27** | **1.35** | **99.57** | **920** | **190** | **145** | **23** | **220** | **39** | 4.6 | 1.03 | 2.2 | 1.3 | 1.4 | 3.8 | 1.7 | 0.12 | |
| WR44 | 14.76 | 1.74 | 0.00 | 3.53 | 4.57 | 0.20 | 0.06 | 3.91 | 0.15 | 68.78 | 0.23 | 2.1 | 100 | 860 | 180 | 150 | 19 | 205 | 31 | 4.7 | 1.01 | 2.2 | 1.2 | 2.1 | 3.9 | 1.7 | 0.20 | |
| WR41 | 13.10 | 1.66 | 0.00 | 3.31 | 4.04 | 0.10 | 0.03 | 3.28 | 0.13 | 71.68 | 0.24 | 2.1 | 99.67 | 790 | 160 | 120 | 23 | 200 | 25 | 5.5 | 1.02 | 2.0 | 1.3 | 2.1 | 3.3 | 1.7 | 0.10 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Coarsely porphyritic (K-spar+plag) rocks** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 446:2942.9 | 15.18 | 2.75 | 0 | 5.73 | 3.31 | 1.06 | 0.07 | 0.14 | 0.05 | 64.4 | 0.21 | 6.38 | 99.28 | 725 | 130 | 308 | 32 | 387 | 46 | 4.2 | 1.72 | 0.1 | 0.4 | 6.4 | 0.1 | 2.8 | 1.06 | y |
| 444:1935.7 | 15.7 | 2.24 | 0 | 2.19 | 6.68 | 0.07 | 0.06 | 1.68 | 0.04 | 66.57 | 0.22 | 3.62 | 99.07 | 885 | 244 | 204 | 30 | 363 | 46 | 4.2 | 1.12 | 0.8 | 1.2 | 3.6 | 1.7 | 2.2 | 0.07 | y |

| | | | | | Table 1. Summary of Chemical Data for Rosebud Volcanic Rocks | | | | | | | | | | | | | | | Alteration screen | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample: | Al2O3 | CaO | Cr2O | Fe2O | K2O | MgO | MnO | Na2 | P2O5 | SiO2 | TiO2 | LOI | Sum | Ba | Rb | Sr | Nb | Zr | Y | Si/Al | A/CNK | Na/Ca | Rb/Sr | LOI | Na2O | CaO | MgO | Alt. |
| 444:1920.4 | 15.56 | 1.57 | 0 | 1.97 | 6.83 | 0.05 | 0.07 | 1.88 | 0.03 | 67.61 | 0.22 | 3.07 | 98.86 | 965 | 236 | 192 | 28 | 381 | 52 | 4.3 | 1.17 | 1.2 | 1.2 | 3.1 | 1.9 | 1.6 | 0.05 | y |
| **444:1727.4** | **15.41** | **1.66** | **0** | **2.02** | **6.45** | **0.03** | **0.05** | **2.39** | **0.05** | **67.89** | **0.22** | **2.7** | **98.87** | **860** | **236** | **176** | **28** | **378** | **40** | 4.4 | 1.11 | 1.4 | 1.3 | 2.7 | 2.4 | 1.7 | 0.03 | y |
| 444:1717.8 | 15.38 | 1.84 | 0 | 1.61 | 6.66 | 0.07 | 0.12 | 2.24 | 0.04 | 68.19 | 0.21 | 2.95 | 99.31 | 840 | 240 | 146 | 30 | 372 | 42 | 4.4 | 1.08 | 1.2 | 1.6 | 3.0 | 2.2 | 1.8 | 0.07 | y |
| 446:2901.1 | 14.38 | 4.27 | 0 | 3.69 | 3.02 | 0.67 | 0.08 | 0.66 | 0.05 | 65.9 | 0.2 | 6.68 | 99.6 | 660 | 110 | 366 | 28 | 369 | 52 | 4.6 | 1.19 | 0.2 | 0.3 | 6.7 | 0.7 | 4.3 | 0.67 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Plagioclase(>10%)-phyric rock with common hornblende** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 422.1:1959.6 | 17.61 | 2.74 | 0 | 4.13 | 3.64 | 0.59 | 0.07 | 4.29 | 0.24 | 61.87 | 0.42 | 4.39 | 99.99 | 1745 | 100 | 716 | 14 | 192 | 14 | 3.5 | 1.10 | 1.6 | 0.1 | 4.4 | 4.3 | 2.7 | 0.59 | y |
| 446:2658.3 | 15.54 | 2.21 | 0 | 3.28 | 1.36 | 0.69 | 0.05 | 5.71 | 0.21 | 66.26 | 0.39 | 3.36 | 99.06 | 940 | 52 | 1035 | 14 | 189 | 18 | 4.3 | 1.04 | 2.6 | 0.1 | 3.4 | 5.7 | 2.2 | 0.69 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Plagioclase(>10%)-phyric rock with common biotite and minor hornblende** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 422.1:1985.1 | 13.64 | 1.76 | 0 | 1.53 | 1.58 | 0.34 | 0.03 | 4.59 | 0.1 | 72.09 | 0.27 | 2.55 | 98.48 | 1060 | 42 | 532 | 22 | 204 | 34 | 5.3 | 1.09 | 2.6 | 0.1 | 2.6 | 4.6 | 1.8 | 0.34 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Microhornblende-rich rocks (amygdaloidal)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 422:2318.1 | 16.41 | 2.23 | 0.02 | 5.04 | 1.92 | 4.32 | 0.05 | 3.75 | 0.26 | 59.21 | 0.68 | 5.69 | 99.58 | 1155 | 78 | 520 | 8 | 135 | 14 | 3.6 | 1.33 | 1.7 | 0.2 | 5.7 | 3.8 | 2.2 | 4.32 | y |
| 422:2141.6 | 15.54 | 2.45 | 0.02 | 6.18 | 2.49 | 2.04 | 0.11 | 4.68 | 0.28 | 60.24 | 0.74 | 4.02 | 98.79 | 1420 | 64 | 684 | 8 | 129 | 14 | 3.9 | 1.05 | 1.9 | 0.1 | 4.0 | 4.7 | 2.5 | 2.04 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Dreamland vitric-lithic lapilli-ash tuff** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 424:2009.6 | 13.54 | 0.64 | 0 | 1.88 | 4.57 | 0.68 | 0.05 | 1.88 | 0.06 | 73.55 | 0.16 | 2.75 | 99.76 | 750 | 166 | 262 | 18 | 186 | 32 | 5.4 | 1.47 | 2.9 | 0.6 | 2.8 | 1.9 | 0.6 | 0.68 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Barrel Springs rocks** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WR166 | 13.02 | 0.9 | 0 | 0.64 | 5.57 | 0.01 | 0.04 | 2.06 | 0.07 | 74.3 | 0.18 | 2.91 | 99.7 | 1400 | 190 | 72 | 20 | 225 | 25 | 5.7 | 1.18 | 2.3 | 2.6 | 2.9 | 2.1 | 0.9 | 0.01 | y |
| WR165 | 10.95 | 0.8 | 0 | 1.02 | 3.81 | 0.22 | 0.01 | 2.46 | 0.06 | 75.79 | 0.15 | 4.21 | 99.48 | 1100 | 130 | 105 | 19 | 205 | 18 | 6.9 | 1.14 | 3.1 | 1.2 | 4.2 | 2.5 | 0.8 | 0.22 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Wildrose Canyon vitrophyre** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WR19 | 13.22 | 1.16 | 0 | 1.83 | 3.03 | 0.1 | 0.07 | 4.4 | 0.06 | 69.11 | 0.08 | 6.77 | 99.83 | 160 | 225 | 350 | 27 | 175 | 39 | 5.2 | 1.05 | 3.8 | 0.6 | 6.8 | 4.4 | 1.2 | 0.10 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Other felsic rocks** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WR30 | 15.64 | 2.36 | 0.00 | 3.82 | 4.67 | 0.25 | 0.04 | 3.57 | 0.17 | 67.28 | 0.43 | 1.84 | 100.1 | 910 | 165 | 190 | 17 | 170 | 23 | 4.3 | 1.03 | 1.5 | 0.9 | 1.8 | 3.6 | 2.4 | 0.25 | |
| WR52 | 14.05 | 4.34 | 0 | 2.72 | 0.71 | 0.09 | 0.06 | 2.84 | 0.12 | 63.71 | 0.18 | 10.5 | 99.31 | 1900 | 34 | 995 | 20 | 145 | 20 | 4.5 | 1.05 | 0.7 | 0.0 | 10.5 | 2.8 | 4.3 | 0.09 | y |
| WR23 | 13.29 | 0.67 | 0.00 | 2.10 | 5.87 | 0.16 | 0.05 | 1.65 | 0.08 | 73.31 | 0.08 | 2.65 | 99.91 | 760 | 230 | 29 | 23 | 185 | 25 | 5.5 | 1.29 | 2.5 | 7.9 | 2.7 | 1.7 | 0.7 | 0.16 | y |
| WR65 | 13.23 | 1.37 | 0.00 | 1.49 | 1.44 | 1.91 | 0.02 | 1.16 | 0.08 | 71.99 | 0.24 | 6.64 | 99.57 | 1100 | 47 | 255 | 25 | 225 | 3 | 5.4 | 2.22 | 0.8 | 0.2 | 6.6 | 1.2 | 1.4 | 1.91 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Andesite and Basalt** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SuK-97-3 | 16.01 | 8.97 | 0 | 12.22 | 0.98 | 6.7 | 0.17 | 2.8 | 0.31 | 47.08 | 1.93 | 1.86 | 99.03 | 350 | 28 | 382 | 8 | 132 | 24 | 2.9 | 0.73 | 0.3 | 0.1 | 1.9 | 2.8 | 9.0 | 6.70 | |
| SK-98-1 | 13.1 | 9.08 | 0 | 9.28 | 1.75 | 10.3 | 0.15 | 2.97 | 0.49 | 47.58 | 1.34 | 2.88 | 98.9 | 1095 | 42 | 862 | 16 | 135 | 18 | 3.6 | 0.56 | 0.3 | 0.0 | 2.9 | 3.0 | 9.1 | 10.28 | |
| F-98-1 | 14.96 | 8.1 | 0 | 12.22 | 1.47 | 4.11 | 0.19 | 3.32 | 0.35 | 50.43 | 2.08 | 1.79 | 99.02 | 605 | 48 | 436 | 12 | 162 | 28 | 3.4 | 0.69 | 0.4 | 0.1 | 1.8 | 3.3 | 8.1 | 4.11 | |
| WR29 | 15.50 | 7.56 | 0.00 | 12.38 | 1.40 | 4.26 | 0.17 | 3.26 | 0.40 | 50.99 | 1.99 | 1.7 | 99.61 | 560 | 24 | 375 | 12 | 160 | 15 | 3.3 | 0.75 | 0.4 | 0.1 | 1.7 | 3.3 | 7.6 | 4.26 | |
| WR8 | 15.60 | 8.22 | 0.00 | 7.40 | 1.82 | 4.16 | 0.13 | 3.56 | 0.43 | 52.69 | 1.04 | 4.66 | 99.71 | 970 | 27 | 820 | 11 | 80 | 3 | 3.4 | 0.69 | 0.4 | 0.0 | 4.7 | 3.6 | 8.2 | 4.16 | y |
| WR33 | 16.35 | 5.17 | 0.00 | 8.64 | 1.69 | 3.19 | 0.11 | 5.54 | 0.46 | 54.48 | 1.08 | 3.18 | 99.89 | 1300 | 16 | 640 | 12 | 105 | 3 | 3.3 | 0.80 | 1.1 | 0.0 | 3.2 | 5.5 | 5.2 | 3.19 | y |
| WR28 | 17.56 | 4.96 | 0.00 | 7.40 | 2.58 | 0.75 | 0.11 | 3.95 | 0.47 | 56.89 | 0.97 | 3.87 | 99.51 | 1500 | 49 | 780 | 10 | 95 | 3 | 3.2 | 0.96 | 0.8 | 0.1 | 3.9 | 4.0 | 5.0 | 0.75 | y |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Alteration: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | y - yes, altered according to chemical criteria | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | tr - trace alteration identified in thin section, for samples which are not chemically altered | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | w - weak alteration identified in hand sample or thin section, for samples which are not chemically altered | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Table 2. Summary of Rock Names for Rosebud Volcanic Rocks Based on Geochemical Classifications** | | | | | | | | | | | | | | | | | | |
| | | TAS Classification: | | | | Normative QAP Classification: | | | | | | | | | For no Corundum: | | | | "Immobile" elements: | | |
| Sample: | Alt. | SiO2* | K2O+Na2O | Name | | Color Ind | Q | or | ab | an | Q! | Plag! | %An | Name | C | Q' | Name' | | Nb/Y | Zr/TiO2 | Name |
| **"Dozer" aphyric rock** | | | | | | | | | | | | | | | | | | | | | |
| 410:943.5 | w | 69.87 | 9.01 | rhy | | 2.01 | 21.4 | 27.8 | 38.6 | 9.3 | 22 | 49.1 | 19 | rhy | 1 | 17.9 | qtzlat | | 0.52 | 0.076 | rhy |
| **410:1047.6** | y | 70.02 | 8.78 | rhy | | 5.39 | 22.8 | 35.8 | 25.6 | 10.4 | 24.1 | 50.1 | 29 | rhy | 0 | 22.8 | rhy | | 0.55 | 0.238 | rhy |
| 454:169.0 | y | 71.90 | 8.30 | rhy | | 3.55 | 31 | 35.6 | 22.2 | 5.7 | 32.8 | 35.9 | 20 | rhy | 2.67 | 21.6 | rhy | | 0.57 | 0.230 | rhy |
| **454:197.3** | y | 72.28 | 8.05 | rhy | | 3.65 | 32.3 | 32.1 | 25.1 | 4.6 | 34.3 | 29.8 | 15 | rhy | 3.21 | 20.9 | rhy | | 0.57 | 0.230 | rhy |
| WR49 | y | 73.79 | 8.59 | rhy | | 2.59 | 32.8 | 32.5 | 28.9 | 0.8 | 34.5 | 5.1 | 3 | afrhy | 3.41 | 20.7 | afrhy | | 0.87 | 0.255 | rhy |
| WR20 | y | 74.44 | 8.41 | rhy | | 2.51 | 33.8 | 33.4 | 25.7 | 2.8 | 35.3 | 18.1 | 10 | rhy | 2.32 | 25.6 | rhy | | 1.07 | 0.281 | comendite |
| WR70 | y | 75.22 | 8.20 | rhy | | 1.43 | 38.7 | 39.1 | 15.9 | 2.2 | 40.4 | 15.4 | 12 | rhy | 3.84 | 25.1 | rhy | | 0.69 | 0.228 | rhy |
| **Deep Dreamland aphyric rock** | | | | | | | | | | | | | | | | | | | | | |
| **425:2159.4** | y | 71.34 | 9.10 | rhy | | 3.16 | 27.3 | 34.8 | 30.3 | 2.1 | 28.9 | 12.5 | 6 | afrhy | 3.48 | 15.0 | qaftry | | 0.57 | 0.248 | rhy |
| 425:2142.8 | | 71.36 | 9.37 | rhy | | 2.27 | 25.2 | 34.2 | 32.7 | 3.8 | 26.3 | 21.5 | 10 | rhy | 2.53 | 16.3 | qtztry | | 0.65 | 0.243 | rhy |
| 444:2046.4 | y | 72.32 | 7.73 | rhy | | 4.06 | 33.8 | 33.5 | 20.5 | 5.9 | 36.1 | 39.4 | 22 | rhy | 3.1 | 22.8 | rhy | | 0.62 | 0.245 | rhy |
| 401:1956.5 | y | 72.96 | 9.10 | rhy | | 2.47 | 29.5 | 35.1 | 29.3 | 1.7 | 30.9 | 10.3 | 5 | afrhy | 2.7 | 20.0 | afrhy | | 0.59 | 0.230 | rhy |
| 450:2045.4 | y | 73.18 | 8.16 | rhy | | 3.55 | 35.3 | 34.8 | 22.5 | 0.6 | 37.9 | 4.1 | 3 | afrhy | 4.76 | 18.5 | qaftry | | 0.62 | 0.251 | rhy |
| 444:2019 | y | 73.31 | 7.30 | rhy | | 4.13 | 40 | 35.9 | 13.8 | 2.2 | 43.5 | 17.0 | 14 | rhy | 5.55 | 20.4 | rhy | | 0.57 | 0.261 | rhy |
| **Shallow Dreamland aphyric rock** | | | | | | | | | | | | | | | | | | | | | |
| 450:1512.1 | y | 69.97 | 8.08 | rhy | | 3.95 | 24.8 | 27.5 | 31.6 | 11.5 | 26 | 61.0 | 27 | rhy | 0.58 | 22.7 | rhy | | 0.59 | 0.231 | rhy |
| 426:1361.2 | y | 71.97 | 9.32 | rhy | | 3.04 | 27.3 | 35.8 | 30.4 | 1.5 | 28.7 | 8.9 | 5 | afrhy | 2.8 | 17.4 | qaftry | | 0.59 | 0.251 | rhy |
| 450:1550.5 | y | 72.61 | 7.88 | rhy | | 3.11 | 35.9 | 33.5 | 22.1 | 1.3 | 38.7 | 9.1 | 6 | afrhy | 5.77 | 15.5 | qaftry | | 0.69 | 0.233 | rhy |
| **Aphyric rocks with mmb** | | | | | | | | | | | | | | | | | | | | | |
| **443:1796.2** | tr | 69.29 | 8.73 | rhy | | 4.71 | 24.3 | 32.2 | 31.2 | 5.7 | 26 | 33.0 | 15 | rhy | 2.61 | 15.1 | qtztry | | 0.60 | 0.104 | rhy |
| 450:1811.2 | y | 70.01 | 8.06 | rhy | | 3.48 | 27.7 | 31.9 | 25.5 | 9.6 | 29.3 | 52.4 | 27 | rhy | 2.51 | 18.8 | qtzlat | | 0.55 | 0.107 | rhy |
| **Sparsely feldspar-phyric rocks (=LBT, Wildrose, brown flow, Brady andesite)** | | | | | | | | | | | | | | | | | | | | | |
| WR12 | | 64.45 | 7.91 | trachyte | | 8.19 | 15.3 | 23.8 | 36.8 | 15 | 16.8 | 68.5 | 29 | and | 0.34 | 14.1 | and | | 1.54 | 0.042 | tryand |
| WR36 | | 64.58 | 7.77 | trachyte | | 8.08 | 16.6 | 24.6 | 34.5 | 15.1 | 18.3 | 66.8 | 30 | and | 0.79 | 13.8 | and | | 1.00 | 0.043 | tryand |
| WR6 | | 66.27 | 8.18 | trachyte | | 7.48 | 15 | 20.6 | 41.1 | 15 | 16.4 | 73.1 | 27 | and | 0.27 | 14.0 | and | | 1.18 | 0.041 | tryand |
| WR45 | | 66.45 | 8.18 | trachyte | | 6.39 | 18.4 | 28.8 | 31.3 | 14.6 | 19.8 | 61.4 | 32 | qtzlat | 0 | 18.4 | qtzlat | | 1.53 | 0.074 | tryand |
| WR13 | | 67.37 | 8.69 | trachyte | | 5.11 | 19.1 | 28.3 | 36.3 | 9.7 | 20.4 | 52.2 | 21 | rhy | 1.49 | 13.8 | qtzlat | | 1.05 | 0.094 | tryand |
| D326:105.0 | y | 67.40 | 8.27 | trachyda | | 5.76 | 21.6 | 30.5 | 29.8 | 11 | 23.3 | 57.2 | 27 | rhy | 1.41 | 16.6 | qtzlat | | 0.53 | 0.070 | rhyodacite |
| WR34 | | 67.44 | 8.61 | trachyte | | 5.2 | 18.6 | 26.7 | 37.8 | 10.9 | 19.8 | 57.8 | 22 | qtzlat | 0.55 | 16.7 | qtzlat | | 1.05 | 0.079 | tryand |
| WR17 | | 67.44 | 7.77 | dacite | | 6.29 | 23.7 | 27.6 | 29.9 | 10.5 | 25.8 | 59.4 | 26 | rhy | 1.72 | 17.6 | qtzlat | | 1.11 | 0.054 | tryand |
| WR10 | | 67.56 | 8.03 | trydac | | 6.07 | 21.7 | 26.2 | 33.9 | 10.6 | 23.5 | 60.0 | 24 | rhy | 1.47 | 16.5 | qtzlat | | 0.79 | 0.074 | tryand |
| WR11 | | 68.21 | 7.87 | dacite | | 5.21 | 24.3 | 26.5 | 31.9 | 10.1 | 26.2 | 59.0 | 24 | rhy | 2.16 | 16.7 | qtzlat | | 1.37 | 0.071 | tryand |
| **NWRA-2603** | tr.c | 68.66 | 8.52 | trydac | | 5.22 | 23.8 | 32.8 | 28.6 | 7.9 | 25.6 | 45.6 | 22 | rhy | 1.66 | 17.9 | qtzlat | | 0.71 | 0.075 | tryand |
| WR18 | | 69.12 | 8.19 | trydac | | 4.38 | 23.7 | 27.8 | 31.1 | 11.3 | 25.2 | 60.4 | 27 | rhy | 1.89 | 17.0 | qtzlat | | 1.33 | 0.088 | tryand |
| WR35 | | 69.16 | 8.53 | rhy | | 3.35 | 22.2 | 37.1 | 36 | 10.1 | 21.1 | 48.6 | 22 | rhy | 1.22 | 17.9 | qtzlat | | 1.00 | 0.098 | tryand |
| WR7 | | 69.22 | 8.80 | rhy | | 4.32 | 21.5 | 27.9 | 37.4 | 7.8 | 22.7 | 42.7 | 17 | rhy | 1.13 | 17.5 | qtzlat | | 1.87 | 0.174 | comendite |
| WR16 | | 69.41 | 8.69 | rhy | | 3.08 | 22.7 | 28.8 | 37.9 | 8.8 | 23.1 | 46.6 | 19 | rhy | 1.93 | 15.9 | qtzlat | | 0.92 | 0.098 | tryand |
| WR14 | | 69.77 | 8.35 | rhy | | 5.13 | 26.4 | 32 | 28.3 | 6.2 | 28.4 | 37.3 | 18 | rhy | 2.36 | 18.1 | qtzlat | | 0.77 | 0.110 | rhy |
| WR71 | y | 70.08 | 8.80 | rhy | | 2.97 | 23.7 | 29.4 | 35.1 | 7.5 | 24.8 | 41.7 | 18 | rhy | 1.75 | 17.5 | qtzlat | | 6.00 | 0.147 | trachyte |
| 446:1918.3 | y | 70.12 | 8.40 | rhy | | 3.26 | 27.3 | 36.4 | 21.8 | 9.5 | 28.7 | 46.2 | 30 | rhy | 2.31 | 19.1 | qtzlat | | 0.59 | 0.206 | rhy |

| | | TAS Classification: | | | Normative QAP Classification: | | | | | | | | | For no Corundum: | | | "Immobile" elements: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample: | Alt. | SiO2* | K2O+Na2O | Name | Color Ind | Q | or | ab | an | Q! | Plag! | %An | Name | C | Q' | Name' | Nb/Y | Zr/TiO2 | Name |
| **WR31** | | 70.43 | 8.74 | rhy | 3.79 | 24.3 | 29.4 | 34.5 | 6.8 | 25.6 | 38.5 | 16 | rhy | 1.34 | 19.6 | qtzlat | 0.92 | 0.178 | comendite |
| NWRA-2601 | tr | 71.14 | 8.70 | rhy | 1.89 | 25.7 | 29.8 | 33.1 | 7.9 | 26.6 | 44.6 | 19 | rhy | 1.8 | 19.3 | qtzlat | 0.57 | 0.183 | rhy |
| 446:1907.2 | y | 71.14 | 7.67 | rhy | 2.92 | 35.1 | 43.7 | 5.5 | 9.9 | 37.3 | 26.1 | 64 | rhy | 3.96 | 21.1 | rhy | 0.56 | 0.190 | rhy |
| **NWRA-2602** | | 71.22 | 8.61 | rhy | 2.13 | 25.5 | 27.3 | 35.9 | 7.8 | 26.4 | 43.9 | 18 | rhy | 1.65 | 19.7 | qtzlat | 0.61 | 0.174 | rhy |
| WR161 | | 71.31 | 8.35 | rhy | 4.33 | 27.7 | 26.6 | 35.6 | 3.7 | 29.6 | 22.5 | 9 | afrhy | 2.53 | 18.8 | qaftry | 1.35 | 0.116 | ? |
| 446:1901.8 | y | 75.67 | 4.04 | rhy | 2.57 | 61.1 | 25.9 | 0 | 1.6 | 69 | 5.8 | 100 | none | 12.5 | 17.0 | none | 0.76 | 0.197 | comendite |
| | | | | | | | | | | | | | | | | | | | |
| **"Chocolate"** | | | | | | | | | | | | | | | | | | | |
| WR5 | | 68.71 | 8.56 | trydac | 4.69 | 22.8 | 30.7 | 31.6 | 8.8 | 24.3 | 49.5 | 22 | rhy | 1.48 | 17.6 | qtzlat | 0.79 | 0.104 | rhy |
| WR15 | | 68.95 | 8.78 | trydac | 5.19 | 25.7 | 40.3 | 20.4 | 6.1 | 27.8 | 36.5 | 23 | rhy | 2.84 | 15.7 | qtzlat | 0.72 | 0.110 | rhy |
| WR74 | | 69.58 | 8.69 | rhy | 3.98 | 24.6 | 32 | 30.9 | 6.5 | 26.2 | 37.5 | 17 | rhy | 2.53 | 15.7 | qtzlat | 5.33 | 0.135 | trachyte |
| WR55 | | 70.21 | 8.78 | rhy | 3.71 | 25 | 33 | 30 | 6.8 | 26.4 | 39.0 | 18 | rhy | 1.7 | 19.0 | qtzlat | 1.14 | 0.169 | comendite? |
| WR72 | | 70.40 | 8.61 | rhy | 3.62 | 24.6 | 28.6 | 34.6 | 7.2 | 25.9 | 40.9 | 17 | rhy | 1.53 | 19.2 | qtzlat | 5.33 | 0.150 | trachyte |
| WR50 | y | 70.76 | 8.66 | rhy | 4.1 | 27.4 | 33.4 | 28.7 | 4.4 | 29.2 | 26.5 | 13 | rhy | 2.62 | 18.1 | qtztry | 0.53 | 0.134 | rhy |
| **WR53** | y | 71.14 | 9.59 | rhy | 2.67 | 23.2 | 34.8 | 33.6 | 4.9 | 24 | 26.7 | 13 | rhy | 0.85 | 20.2 | rhy | 0.63 | 0.118 | rhy |
| WR39 | | 71.22 | 8.38 | rhy | 2.45 | 26.1 | 29.2 | 31.2 | 10.7 | 26.9 | 58.9 | 26 | rhy | 0 | 26.1 | rhy | 0.65 | 0.057 | dacite |
| WR51 | y | 74.01 | 7.02 | rhy | 3.97 | 43.4 | 36.6 | 10.6 | 1.2 | 47.3 | 9.9 | 10 | afrhy | 5.92 | 22.5 | afrhy | 0.78 | 0.084 | tryand |
| WR3 | y | 78.29 | 5.02 | rhy | 1.71 | 59 | 30.4 | 1.8 | 1 | 64 | 8.4 | 36 | none | 8.72 | 28.2 | none | 1.61 | 0.077 | tryand |
| | | | | | | | | | | | | | | | | | | | |
| **Feldspar-phyric rocks with mmb and locally rare quartz phenocrysts** | | | | | | | | | | | | | | | | | | | |
| 443:1564.0 | y | 70.98 | 7.28 | rhy | 4.59 | 32.4 | 30.9 | 20.4 | 9.5 | 34.8 | 49.2 | 32 | rhy | 2.86 | 22.3 | rhy | 0.67 | 0.226 | rhy |
| 445:1864.3 | y | 71.50 | 7.50 | rhy | 3.3 | 33.7 | 38.9 | 10.6 | 11.9 | 35.4 | 36.6 | 53 | rhy | 2.17 | 26.0 | rhy | 0.65 | 0.152 | rhy |
| **444:1597.2** | tr | 73.13 | 8.21 | rhy | 2.6 | 32 | 33.2 | 24.3 | 6.6 | 33.3 | 41.2 | 21 | rhy | 1.68 | 26.1 | rhy | 0.60 | 0.129 | rhy |
| 445:1906.0 | y | 74.01 | 6.84 | rhy | 3.1 | 40.2 | 32.6 | 13.9 | 7.7 | 42.6 | 39.9 | 36 | rhy | 3.39 | 28.2 | rhy | 0.60 | 0.152 | rhy |
| 445:1853.4 | y | 74.24 | 5.65 | rhy | 2.91 | 49.7 | 34.8 | 1.1 | 6.1 | 54.2 | 17.1 | 85 | none | 7.65 | 22.6 | none | 0.59 | 0.143 | rhy |
| 445:1777.0 | y | 75.71 | 2.89 | dacite | 3.43 | 66.4 | 18.8 | 0.1 | 1 | 76.9 | 5.5 | 91 | none | 14.5 | 15.2 | none | 0.55 | 0.156 | rhy |
| 445:1793.6 | y | 77.20 | 4.40 | rhy | 2.13 | 61.2 | 28 | 0 | 1 | 67.8 | 3.4 | 100 | none | 10.9 | 22.6 | none | 0.58 | 0.164 | rhy |
| | | | | | | | | | | | | | | | | | | | |
| **Porphyritic "Chocolate" or "intrusions"** | | | | | | | | | | | | | | | | | | | |
| WR4 | | 62.90 | 8.42 | trachyte | 10.03 | 11.6 | 26.4 | 38 | 13.2 | 13 | 66.0 | 26 | and | 0 | 11.6 | and | 0.80 | 0.027 | tryand |
| WR61 | | 63.57 | 8.08 | trachyte | 9.28 | 15 | 27.6 | 33.4 | 13.6 | 16.7 | 63.0 | 29 | qtzlat | 0.54 | 13.1 | qtzlat | 0.79 | 0.033 | tryand |
| WR21 | | 64.98 | 8.66 | trachyte | 7.78 | 18.2 | 32.3 | 31.8 | 7.6 | 20.2 | 42.4 | 19 | qtzlat | 2.39 | 9.7 | qtzlat | 0.69 | 0.039 | tryand |
| WR47 | | 68.38 | 9.05 | trachyte | 5.76 | 19.2 | 31.3 | 34.9 | 8.5 | 20.4 | 45.5 | 20 | rhy | 0 | 19.2 | qtzlat | 0.83 | 0.090 | tryand |
| | | | | | | | | | | | | | | | | | | | |
| **West Kamma Peak intrusions** | | | | | | | | | | | | | | | | | | | |
| WR38 | | 66.13 | 8.35 | trachyte | 6.26 | 17.4 | 25.8 | 37.2 | 12.3 | 18.8 | 65.3 | 25 | and | 0.9 | 14.2 | and | 1.21 | 0.080 | tryand |
| WR37 | | 68.47 | 8.85 | trydac | 4.79 | 20.2 | 28.9 | 36.6 | 8.5 | 21.4 | 45.9 | 19 | rhy | 0.98 | 16.7 | qtzlat | 1.05 | 0.144 | comendite? |
| | | | | | | | | | | | | | | | | | | | |
| **Lantern intrusions** | | | | | | | | | | | | | | | | | | | |
| **WR40** | | 70.17 | 8.59 | rhy | 4.35 | 24.2 | 29.4 | 33.5 | 7.8 | 25.5 | 44.1 | 19 | rhy | 0.7 | 21.7 | rhy | 0.59 | 0.081 | dacite |
| WR44 | | 70.23 | 8.66 | rhy | 4.36 | 23.6 | 28.9 | 34.7 | 7.8 | 24.8 | 43.7 | 18 | rhy | 0.5 | 21.8 | rhy | 0.61 | 0.089 | dacite |
| WR41 | y | 73.47 | 7.50 | rhy | 3.89 | 33.1 | 25.6 | 29.2 | 7.6 | 34.7 | 48.7 | 21 | rhy | 0.56 | 31.1 | rhy | 0.92 | 0.083 | tryand |
| | | | | | | | | | | | | | | | | | | | |
| **Coarsely porphyritic (K-spar+plag) rocks** | | | | | | | | | | | | | | | | | | | |
| 446:2942.9 | y | 69.32 | 3.71 | dacite | 9.39 | 46.1 | 23.2 | 1.4 | 14.9 | 53.9 | 41.3 | 91 | rhy | 6.91 | 21.7 | rhy | 0.70 | 0.184 | rhy |
| 444:1935.7 | y | 69.74 | 8.76 | rhy | 2.68 | 26.5 | 43.1 | 15.2 | 11.3 | 27.6 | 38.1 | 43 | rhy | 1.7 | 20.5 | rhy | 0.65 | 0.165 | rhy |

| | | TAS Classification: | | | Normative QAP Classification: | | | | | | | | | For no Corundum: | | | "Immobile" elements: | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample: | Alt. | SiO2* | K2O+Na2O | Name | Color Ind | Q | or | ab | an | Q! | Plag! | %An | Name | C | Q' | Name' | Nb/Y | Zr/TiO2 | Name |
| 444:1920.4 | y | 70.58 | 9.09 | rhy | 2.39 | 27.3 | 43.9 | 16.9 | 7.9 | 28.4 | 36.1 | 32 | rhy | 2.28 | 19.2 | qtzlat | 0.54 | 0.173 | rhy |
| **444:1727.4** | y | 70.59 | 9.19 | rhy | 2.37 | 25.7 | 41.2 | 21.4 | 8.2 | 26.6 | 41.8 | 28 | rhy | 1.56 | 20.2 | rhy | 0.70 | 0.172 | rhy |
| 444:1717.8 | y | 70.77 | 9.24 | rhy | 2.07 | 25.7 | 42.3 | 20 | 9.1 | 26.5 | 40.8 | 31 | rhy | 1.19 | 21.5 | rhy | 0.71 | 0.177 | rhy |
| 446:2901.1 | y | 70.92 | 3.96 | dacite | 5.9 | 42.7 | 20.6 | 6.3 | 22.6 | 46.3 | 58.4 | 78 | rhy | 2.47 | 34.0 | rhy | 0.54 | 0.185 | rhy |
| | | | | | | | | | | | | | | | | | | | |
| **Plagioclase(>10%)-phyric rock with common hornblende** | | | | | | | | | | | | | | | | | | | |
| 422.1:1959.6 | y | 64.72 | 8.29 | trachyte | 5.99 | 15.5 | 23.9 | 39.6 | 13 | 16.8 | 68.0 | 25 | and | 2.09 | 8.1 | and | 1.00 | 0.046 | tryand |
| 446:2658.3 | y | 69.24 | 7.39 | dacite | 5.14 | 22.2 | 8.9 | 52.3 | 10.4 | 23.7 | 58.1 | 17 | rhy | 1.02 | 18.6 | qtzlat | 0.78 | 0.048 | tryand |
| | | | | | | | | | | | | | | | | | | | |
| **Plagioclase(>10%)-phyric rock with common biotite and minor hornblende** | | | | | | | | | | | | | | | | | | | |
| 422.1:1985.1 | y | 75.15 | 6.43 | rhy | 2.39 | 36.3 | 10.2 | 41.4 | 8.6 | 37.6 | 57.1 | 17 | rhy | 1.33 | 31.6 | rhy | 0.65 | 0.076 | dacite |
| | | | | | | | | | | | | | | | | | | | |
| **Microhornblende-rich rocks (amygdaloidal)** | | | | | | | | | | | | | | | | | | | |
| 422:2318.1 | y | 63.06 | 6.04 | dacite | 15.33 | 19.4 | 13.5 | 37 | 10.8 | 24 | 70.5 | 23 | dacite | 4.9 | 2.1 | and | 0.57 | 0.020 | and |
| 422:2141.6 | y | 63.56 | 7.57 | trachyte | 11.61 | 13.9 | 16.9 | 44.6 | 11.5 | 16 | 63.0 | 20 | qtzlat | 1.25 | 9.5 | qtzlat | 0.57 | 0.017 | and |
| | | | | | | | | | | | | | | | | | | | |
| **Dreamland vitric-lithic lapilli-ash tuff** | | | | | | | | | | | | | | | | | | | |
| 424:2009.6 | y | 75.82 | 6.65 | rhy | 3.49 | 43.9 | 29.4 | 16.9 | 3 | 47.1 | 24.3 | 15 | rhy | 4.52 | 27.9 | rhy | 0.56 | 0.116 | rhy |
| | | | | | | | | | | | | | | | | | | | |
| **Barrel Springs rocks** | | | | | | | | | | | | | | | | | | | |
| WR166 | y | 76.76 | 7.88 | rhy | 0.76 | 40.1 | 35.1 | 18.2 | 4.3 | 41 | 29.9 | 19 | rhy | 2.08 | 32.7 | rhy | 0.80 | 0.125 | rhy |
| WR165 | y | 79.55 | 6.58 | rhy | | | | | | | | | | | | | 1.06 | 0.137 | ? |
| | | | | | | | | | | | | | | | | | | | |
| **Wildrose Canyon vitrophyre** | | | | | | | | | | | | | | | | | | | |
| WR19 | y | 74.26 | 7.98 | rhy | 2.42 | 30.5 | 20 | 40.7 | 5.7 | 31.5 | 34.3 | 12 | rhy | 0.73 | 27.9 | rhy | 0.69 | 0.219 | rhy |
| | | | | | | | | | | | | | | | | | | | |
| **Other felsic rocks** | | | | | | | | | | | | | | | | | | | |
| WR30 | | 68.49 | 8.39 | trydac | 4.73 | 22.3 | 29.6 | 31.7 | 10.8 | 23.6 | 58.9 | 25 | rhy | 0.75 | 19.6 | qtzlat | 0.74 | 0.040 | tryand |
| WR52 | y | 71.73 | 4.00 | rhy | 1.99 | 40.4 | 5 | 28 | 23.7 | 41.6 | 91.2 | 46 | dacite | 0.87 | 37.3 | dacite | 1.00 | 0.081 | tryand |
| WR23 | y | 75.38 | 7.73 | rhy | 2.71 | 40 | 37.3 | 14.7 | 3 | 42.1 | 21.8 | 17 | rhy | 3.21 | 28.6 | rhy | 0.92 | 0.231 | rhy |
| WR65 | y | 77.47 | 2.80 | rhy | 5.76 | 60.3 | 9.9 | 11.2 | 7.1 | 68.1 | 64.9 | 39 | none | 7.91 | 32.3 | none | 8.33 | 0.094 | basanite |
| | | | | | | | | | | | | | | | | | | | |
| **Andesite and Basalt** | | | | | | | | | | | | | | | | | | | |
| SuK-97-3 | | 48.45 | 3.89 | basalt | 32.2 | 0 | 7 | 28.2 | 31.9 | 0 | 89.6 | 53 | basalt | 0 | 0.0 | basalt | 0.33 | 0.007 | basalt |
| SK-98-1 | | 49.55 | 4.92 | basalt | 38.61 | 0 | 12.7 | 25 | 19.7 | 0 | 77.9 | 44 | basalt | 0 | 0.0 | basalt | 0.89 | 0.010 | alkali basalt |
| F-98-1 | | 51.87 | 4.93 | basalt | 30.76 | 0.5 | 10.5 | 33.2 | 24.2 | 0.73 | 84.5 | 42 | basalt | 0 | 0.5 | basalt | 0.43 | 0.008 | basalt |
| WR29 | | 52.08 | 4.76 | basand | 24.93 | 5.9 | 9.9 | 32.3 | 26.1 | 7.95 | 85.5 | 45 | and | 0 | 5.9 | and | 0.80 | 0.008 | alkali basalt |
| WR8 | y | 55.43 | 5.66 | shosh. | 22.79 | 4.6 | 12.8 | 35.2 | 23.5 | 6.04 | 82.1 | 40 | and | 0 | 4.6 | and | 3.67 | 0.008 | alkali basalt |
| WR33 | y | 56.33 | 7.48 | benmor | 18.82 | 0 | 11.5 | 52.9 | 15.8 | 0 | 85.7 | 23 | and | 0 | 0.0 | and | 4.00 | 0.010 | alkali basalt |
| WR28 | y | 59.48 | 6.83 | latite | 10.3 | 10.5 | 17.4 | 37.3 | 23.4 | 11.9 | 77.7 | 39 | and | 0.19 | 9.8 | and | 3.33 | 0.010 | alkali basalt |

* normalized to 100% volatile free
! normalized to 100% quartz and feldspar
' recalculated corundum free

afrhy alkali-feldspar rhyolite
qtzlat quartz latite
qtztry quartz trachyte
qaftry quartz alkali-feldspar trachyte
rhy rhyolite

tryand trachyandesite
trydac trachydacite

and andesite
benmor benmoreite
basand basaltic andesite
shosh shoshonite

**Table 3. Summary of Petrogenetic Parameters for Rosebud Volcanic Rocks**

| | | Normalized to "0" LOI: | | | Element Ratios: | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sample: | Alt. | SiO2 | Al2O3 | K2O | Zr/Y | (Zr*100)/TiO | 10*Nb/Zr | Rb/Sr | K20/Rb |
| **"Dozer" aphyric rock** | | | | | | | | | |
| 410:943.5 | w | 69.87 | 16.84 | 4.53 | 6.4 | 7.6 | 0.82 | 0.77 | 311 |
| **410:1047.6** | y | 70.02 | 15.11 | 5.81 | 7.1 | 23.8 | 0.77 | 0.79 | 329 |
| 454:169.0 | y | 71.90 | 15.25 | 5.75 | 6.6 | 23.0 | 0.87 | 2.11 | 279 |
| **454:197.3** | y | 72.28 | 15.28 | 5.17 | 6.6 | 23.0 | 0.87 | 2.11 | 269 |
| WR49 | y | 73.79 | 14.89 | 5.26 | 9.0 | 25.5 | 0.96 | 3.98 | 295 |
| WR20 | y | 74.44 | 14.18 | 5.42 | 8.0 | 28.1 | 1.33 | 7.50 | 251 |
| WR70 | y | 75.22 | 14.61 | 6.36 | 5.3 | 22.8 | 1.32 | 4.09 | 272 |
| | | | | | | | | | |
| **Deep Dreamland aphyric rock** | | | | | | | | | |
| **425:2159.4** | y | 71.34 | 16.08 | 5.61 | 6.5 | 24.8 | 0.88 | 1.90 | 276 |
| 425:2142.8 | | 71.36 | 16.26 | 5.57 | 6.3 | 24.3 | 1.03 | 1.56 | 295 |
| 444:2046.4 | y | 72.32 | 15.02 | 5.37 | 6.4 | 24.5 | 0.96 | 1.17 | 267 |
| 401:1956.5 | y | 72.96 | 15.11 | 5.70 | 6.3 | 23.0 | 0.94 | 1.94 | 282 |
| 450:2045.4 | y | 73.18 | 15.27 | 5.58 | 6.6 | 25.1 | 0.94 | 1.42 | 285 |
| 444:2019 | y | 73.31 | 15.17 | 5.72 | 6.2 | 26.1 | 0.92 | 0.87 | 277 |
| | | | | | | | | | |
| **Shallow Dreamland aphyric rock** | | | | | | | | | |
| 450:1512.1 | y | 69.97 | 15.73 | 4.45 | 11.6 | 23.1 | 0.51 | 0.76 | 286 |
| 426:1361.2 | y | 71.97 | 15.42 | 5.81 | 6.3 | 25.1 | 0.94 | 2.13 | 298 |
| 450:1550.5 | y | 72.61 | 16.22 | 5.36 | 13.1 | 23.3 | 0.52 | 0.90 | 276 |
| | | | | | | | | | |
| **Aphyric rocks with mmb** | | | | | | | | | |
| **443:1796.2** | tr | 69.29 | 16.19 | 5.16 | 7.8 | 10.4 | 0.77 | 0.74 | 305 |
| 450:1811.2 | y | 70.01 | 16.49 | 5.13 | 7.5 | 10.7 | 0.73 | 0.90 | 269 |
| | | | | | | | | | |
| **Sparsely feldspar-phyric rocks (=LBT, Wildrose, brown flow, Brady andesite)** | | | | | | | | | |
| WR12 | | 64.45 | 16.79 | 3.77 | 19.6 | 4.2 | 0.78 | 0.43 | 283 |
| WR36 | | 64.58 | 16.94 | 3.88 | 12.4 | 4.3 | 0.81 | 0.46 | 270 |
| WR6 | | 66.27 | 17.59 | 3.38 | 13.0 | 4.1 | 0.91 | 0.37 | 266 |
| WR45 | | 66.45 | 16.33 | 4.60 | 18.3 | 7.4 | 0.84 | 0.56 | 288 |
| WR13 | | 67.37 | 16.88 | 4.54 | 14.3 | 9.4 | 0.73 | 0.61 | 285 |
| D326:105.0 | y | 67.40 | 16.37 | 4.87 | 8.6 | 7.0 | 0.61 | 0.66 | 270 |
| WR34 | | 67.44 | 16.40 | 4.28 | 15.0 | 7.9 | 0.70 | 0.60 | 281 |
| WR17 | | 67.44 | 15.92 | 4.38 | 13.4 | 5.4 | 0.82 | 0.61 | 290 |
| WR10 | | 67.56 | 16.29 | 4.17 | 11.7 | 7.4 | 0.68 | 0.55 | 302 |
| WR11 | | 68.21 | 16.49 | 4.24 | 15.0 | 7.1 | 0.91 | 0.62 | 285 |
| **NWRA-2603** | tr.c | 68.66 | 15.69 | 5.25 | 9.9 | 7.5 | 0.72 | 0.74 | 328 |
| WR18 | | 69.12 | 17.14 | 4.56 | 16.7 | 8.8 | 0.80 | 0.64 | 297 |
| WR35 | | 69.16 | 16.60 | 4.38 | 14.5 | 9.8 | 0.69 | 0.61 | 277 |
| WR7 | | 69.22 | 16.02 | 4.50 | 22.0 | 17.4 | 0.85 | 0.74 | 276 |
| WR16 | | 69.41 | 16.91 | 4.67 | 12.7 | 9.8 | 0.72 | 0.61 | 302 |
| WR14 | | 69.77 | 15.51 | 5.11 | 11.0 | 11.0 | 0.70 | 1.06 | 263 |
| WR71 | y | 70.08 | 16.39 | 4.75 | 88.3 | 14.7 | 0.68 | 0.97 | 275 |
| 446:1918.3 | y | 70.12 | 16.39 | 5.88 | 10.3 | 20.6 | 0.57 | 0.97 | 251 |

| | | Normalized to "0" LOI: | | | Element Ratios: | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sample: | Alt. | SiO2 | Al2O3 | K2O | Zr/Y | (Zr*100)/TiO | 10*Nb/Zr | Rb/Sr | K20/Rb |
| **WR31** | | 70.43 | 15.59 | 4.76 | 12.8 | 17.8 | 0.72 | 0.92 | 284 |
| NWRA-2601 | tr | 71.14 | 16.41 | 4.86 | 8.3 | 18.3 | 0.69 | 0.92 | 274 |
| 446:1907.2 | y | 71.14 | 16.36 | 7.04 | 9.5 | 19.0 | 0.58 | 2.43 | 269 |
| **NWRA-2602** | | 71.22 | 16.31 | 4.44 | 9.7 | 17.4 | 0.63 | 0.86 | 261 |
| WR161 | | 71.31 | 15.26 | 4.27 | 17.1 | 11.6 | 0.79 | 0.85 | 363 |
| 446:1901.8 | y | 75.67 | 17.44 | 4.04 | 11.6 | 19.7 | 0.66 | 7.67 | 207 |
| | | | | | | | | | |
| **"Chocolate"** | | | | | | | | | |
| WR5 | | 68.71 | 16.08 | 4.94 | 12.1 | 10.4 | 0.66 | 1.06 | 274 |
| WR15 | | 68.95 | 15.94 | 6.45 | 9.8 | 11.0 | 0.74 | 1.62 | 297 |
| WR74 | | 69.58 | 16.37 | 5.15 | 90.0 | 13.5 | 0.59 | 1.06 | 278 |
| WR55 | | 70.21 | 15.74 | 5.33 | 16.9 | 16.9 | 0.68 | 1.00 | 304 |
| WR72 | | 70.40 | 15.82 | 4.62 | 85.0 | 15.0 | 0.63 | 0.94 | 293 |
| WR50 | y | 70.76 | 15.50 | 5.37 | 6.3 | 13.4 | 0.85 | 2.95 | 229 |
| **WR53** | y | 71.14 | 15.29 | 5.68 | 7.5 | 11.8 | 0.84 | 1.65 | 293 |
| WR39 | | 71.22 | 15.17 | 4.75 | 6.3 | 5.7 | 1.02 | 1.29 | 257 |
| WR51 | y | 74.01 | 14.65 | 5.82 | 6.6 | 8.4 | 1.19 | 7.26 | 251 |
| WR3 | y | 78.29 | 14.68 | 4.82 | 13.3 | 7.7 | 1.21 | 5.77 | 205 |
| | | | | | | | | | |
| **Feldspar-phyric rocks with mmb and locally rare quartz phenocrysts** | | | | | | | | | |
| 443:1564.0 | y | 70.98 | 15.61 | 4.95 | 12.8 | 22.6 | 0.52 | 0.90 | 243 |
| 445:1864.3 | y | 71.50 | 15.47 | 6.28 | 6.1 | 15.2 | 1.07 | 1.16 | 270 |
| **444:1597.2** | tr | 73.13 | 14.66 | 5.39 | 5.5 | 12.9 | 1.10 | 1.22 | 246 |
| 445:1906.0 | y | 74.01 | 14.60 | 5.25 | 6.1 | 15.2 | 0.99 | 1.68 | 236 |
| 445:1853.4 | y | 74.24 | 16.12 | 5.52 | 5.9 | 14.3 | 1.01 | 2.48 | 250 |
| 445:1777.0 | y | 75.71 | 17.96 | 2.88 | 5.6 | 15.6 | 0.98 | 3.55 | 172 |
| 445:1793.6 | y | 77.20 | 16.07 | 4.39 | 6.0 | 16.4 | 0.96 | 4.38 | 226 |
| | | | | | | | | | |
| **Porphyritic "Chocolate" or "intrusions"** | | | | | | | | | |
| WR4 | | 62.90 | 16.34 | 4.15 | 8.6 | 2.7 | 0.93 | 0.60 | 246 |
| WR61 | | 63.57 | 16.37 | 4.34 | 7.4 | 3.3 | 1.06 | 0.67 | 263 |
| WR21 | | 64.98 | 16.57 | 5.08 | 6.5 | 3.9 | 1.05 | 1.21 | 242 |
| WR47 | | 68.38 | 15.25 | 5.04 | 9.0 | 9.0 | 0.93 | 1.30 | 251 |
| | | | | | | | | | |
| **West Kamma Peak intrusions** | | | | | | | | | |
| WR38 | | 66.13 | 16.88 | 4.12 | 17.4 | 8.0 | 0.70 | 0.48 | 300 |
| WR37 | | 68.47 | 16.12 | 4.65 | 17.9 | 14.4 | 0.59 | 0.67 | 307 |
| | | | | | | | | | |
| **Lantern intrusions** | | | | | | | | | |
| **WR40** | | 70.17 | 15.13 | 4.73 | 5.6 | 8.1 | 1.05 | 1.31 | 245 |
| WR44 | | 70.23 | 15.07 | 4.67 | 6.6 | 8.9 | 0.93 | 1.20 | 254 |
| WR41 | y | 73.47 | 13.43 | 4.14 | 8.0 | 8.3 | 1.15 | 1.33 | 253 |
| | | | | | | | | | |
| **Coarsely porphyritic (K-spar+plag) rocks** | | | | | | | | | |
| 446:2942.9 | y | 69.32 | 16.34 | 3.56 | 8.4 | 18.4 | 0.83 | 0.42 | 255 |
| 444:1935.7 | y | 69.74 | 16.45 | 7.00 | 7.9 | 16.5 | 0.83 | 1.20 | 274 |

| | | Normalized to "0" LOI: | | | Element Ratios: | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sample: | Alt. | SiO2 | Al2O3 | K2O | Zr/Y | (Zr*100)/TiO | 10*Nb/Zr | Rb/Sr | K20/Rb |
| 444:1920.4 | y | 70.58 | 16.24 | 7.13 | 7.3 | 17.3 | 0.73 | 1.23 | 289 |
| **444:1727.4** | y | 70.59 | 16.02 | 6.71 | 9.5 | 17.2 | 0.74 | 1.34 | 273 |
| 444:1717.8 | y | 70.77 | 15.96 | 6.91 | 8.9 | 17.7 | 0.81 | 1.64 | 278 |
| 446:2901.1 | y | 70.92 | 15.48 | 3.25 | 7.1 | 18.5 | 0.76 | 0.30 | 275 |
| | | | | | | | | | |
| **Plagioclase(>10%)-phyric rock with common hornblende** | | | | | | | | | |
| 422.1:1959.6 | y | 64.72 | 18.42 | 3.81 | 13.7 | 4.6 | 0.73 | 0.14 | 364 |
| 446:2658.3 | y | 69.24 | 16.24 | 1.42 | 10.5 | 4.8 | 0.74 | 0.05 | 262 |
| | | | | | | | | | |
| **Plagioclase(>10%)-phyric rock with common biotite and minor hornblende** | | | | | | | | | |
| 422.1:1985.1 | y | 75.15 | 14.22 | 1.65 | 6.0 | 7.6 | 1.08 | 0.08 | 376 |
| | | | | | | | | | |
| **Microhornblende-rich rocks (amygdaloidal)** | | | | | | | | | |
| 422:2318.1 | y | 63.06 | 17.48 | 2.04 | 9.6 | 2.0 | 0.59 | 0.15 | 246 |
| 422:2141.6 | y | 63.56 | 16.40 | 2.63 | 9.2 | 1.7 | 0.62 | 0.09 | 389 |
| | | | | | | | | | |
| **Dreamland vitric-lithic lapilli-ash tuff** | | | | | | | | | |
| 424:2009.6 | y | 75.82 | 13.96 | 4.71 | 5.8 | 11.6 | 0.97 | 0.63 | 275 |
| | | | | | | | | | |
| **Barrel Springs rocks** | | | | | | | | | |
| WR166 | y | 76.76 | 13.45 | 5.75 | 9.0 | 12.5 | 0.89 | 2.64 | 293 |
| WR165 | y | 79.55 | 11.49 | 4.00 | 11.4 | 13.7 | 0.93 | 1.24 | 293 |
| | | | | | | | | | |
| **Wildrose Canyon vitrophyre** | | | | | | | | | |
| WR19 | y | 74.26 | 14.21 | 3.26 | 4.5 | 21.9 | 1.54 | 0.64 | 135 |
| | | | | | | | | | |
| **Other felsic rocks** | | | | | | | | | |
| WR30 | | 68.49 | 15.92 | 4.75 | 7.4 | 4.0 | 1.00 | 0.87 | 283 |
| WR52 | y | 71.73 | 15.82 | 0.80 | 7.3 | 8.1 | 1.38 | 0.03 | 209 |
| WR23 | y | 75.38 | 13.66 | 6.04 | 7.4 | 23.1 | 1.24 | 7.93 | 255 |
| WR65 | y | 77.47 | 14.24 | 1.55 | 75.0 | 9.4 | 1.11 | 0.18 | 306 |
| | | | | | | | | | |
| **Andesite and Basalt** | | | | | | | | | |
| SuK-97-3 | | 48.45 | 16.48 | 1.01 | 5.5 | 0.7 | 0.61 | 0.07 | 350 |
| SK-98-1 | | 49.55 | 13.64 | 1.82 | 7.5 | 1.0 | 1.19 | 0.05 | 417 |
| F-98-1 | | 51.87 | 15.39 | 1.51 | 5.8 | 0.8 | 0.74 | 0.11 | 306 |
| WR29 | | 52.08 | 15.83 | 1.43 | 10.7 | 0.8 | 0.75 | 0.06 | 583 |
| WR8 | y | 55.43 | 16.41 | 1.91 | 26.7 | 0.8 | 1.38 | 0.03 | 674 |
| WR33 | y | 56.33 | 16.91 | 1.75 | 35.0 | 1.0 | 1.14 | 0.03 | 1056 |
| WR28 | y | 59.48 | 18.36 | 2.70 | 31.7 | 1.0 | 1.05 | 0.06 | 527 |
| | | | | | | | | | |
| | | Samples with bold sample numbers are considered most representative of their respective categories. | | | | | | | |

**Table 4. Sample Locations and Descriptions of Rosebud Volcanic Rocks**

| Sample: | Location | Description | Lac* Map | Name | Brady Map unit | Comments |
|---|---|---|---|---|---|---|
| **"Dozer" aphyric rock** | | | | | | |
| 410:943.5 | East Zone | greenish-grey, aphyric rock with caraway seed texture ("Dozer"); weak green clay, calcite | | | | |
| **410:1047.6** | East Zone | grey, aphyric rock ("Dozer"); calcite | | | | |
| 454:169.0 | S. of East Zone | grey, aphyric rock with black microspeckles ("Dozer"); calcite | | | | |
| **454:197.3** | S. of East Zone | grey, aphyric rock with very rare feld phenos ("Dozer"); calcite | | | | |
| WR49 | bottom N. side of South Ridge | light green tuff | Tdt | ? | Td | |
| WR20 | N. side W. end Wildrose Canyon | flow-banded | Tdt | ? | Td | Moore's rhyolite dome, "Twd" |
| WR70 | Juniper Canyon | ? | Tdt | ? | Tdi | |
| | | | | | | |
| **Deep Dreamland aphyric rock** | | | | | | |
| **425:2159.4** | Dreamland | grey, aphyric rock with black microspeckles; calcite | | | | |
| 425:2142.8 | Dreamland | weakly bleached aphyric rock with green specks; calcite | | | | |
| 444:2046.4 | Dreamland | pseudobreccia with v. rare feld phenos; calcite, weak arg. & green clay | | | | |
| 401:1956.5 | Dreamland | grey, aphyric rock; calcite | | | | |
| 450:2045.4 | Dreamland | pseudobreccia with v. rare feld phenos; weak arg. & tr. green clay | | | | |
| 444:2019 | Dreamland | brecciated aphyric rock; calcite | | | | |
| | | | | | | |
| **Shallow Dreamland aphyric rock** | | | | | | |
| 450:1512.1 | Dreamland | brecciated aphyric rock: calcite, weak green clay & arg? | | | | |
| 426:1361.2 | Lucky Boy | grey, aphyric rock; calcite | | | | |
| 450:1550.5 | Dreamland | aphyric rock with microspherulitic? texture; calcite, weak green clay | | | | |
| | | | | | | |
| **Aphyric rocks with mmb** | | | | | | |
| **443:1796.2** | Dreamland | brecciated aphyric rock with about 5% mmb; calcite | | | | |
| 450:1811.2 | Dreamland | aphyric rock with about 2% mmb; calcite | | | | |
| | | | | | | |
| **Sparsely feldspar-phyric rocks (=LBT, Wildrose, brown flow, Brady andesite)** | | | | | | |
| WR12 | Wildrose Spring | ? | Tcf | WR tuff; green Choc | Tbf | Moore's Twr, like WR13 |
| WR36 | E. of ZZ Top | intrusion | Tcf | ? | Ta | RB-28: trachytic basalt with plag (An59) and altered mafic phenos |
| WR6 | S. of W. end Wildrose Canyon | ? | Tbb2 | WR pyro; Bud Bx | Tbf | Moore's Goblin Gulch dacite, "Tgg" |
| WR45 | Little Choc. Hill, South Ridge | purple grey felsite | Tcf | sill; Choc | Ta | THE Brady Andesite |
| WR13 | Wildrose Spring | blue flow-banded | Tcf | WR tuff; Choc | Tbf | RB-31: non-aligned feldspar laths; rare plag, px phenos; weak clay, hem |
| D326:105.0 | North Zone | red brown rock with very rare feld phenosand rare mmb; calcite | | | | |
| WR34 | SW. of Rosebud Peak | platy, flow-banded | Tcf | Choc | Tc | Moore's Twr |
| WR17 | E. of ZZ Top | flow-banded | Tcf | eruptive vent | Ta | Moore's "latite?" intrusion; same unit as WR36 and NWRA2603 |
| WR10 | N. side Wildrose Canyon | ? | Tbb2 | WR pyro; Bud Bx | Tbf | Moore's Knob Gulch dacite, "Tkg" |
| WR11 | N. side Wildrose Canyon | ? | Tbb2 | WR pyro; Bud Bx | Tbf | Moore's Knob Gulch dacite, "Tkg" |
| **NWRA-2603** | in draw E. of ZZ Top | red-grey rock with very rare feld phenos in felted microlite matrix | | | | |
| WR18 | S. of W. end Wildrose Canyon | basalt | Til | WR tuff | Tbf | |
| WR35 | E. of Gator, low hill N. of 1739m | flow-banded | Tcf | Choc | Ta | Moore's Tct "rhyolite, resembles Twr" |
| WR7 | NW. of USMM212 (N. Equinox), S. of Wildrose Cany | ? | Tir | intrusion | Tbf | Moore's Knob Gulch dacite, "Tkg"; same? unit as NWRA-2602 |
| WR16 | N. of Wildrose Canyon | grey felsite | Tcf | WR tuff; Choc | Tbf | Moore's foliated rhyolite, "Twr" |
| WR14 | N. of Juniper Canyon, S. side of hill 1884m | grey purple felsite | Tcf | "sill?" | Tbf | Moore's aphyric rhyolite, "Tbw" |
| WR71 | NW. of Rosebud Peak | ? | Tdt | ? | Tbf | |
| 446:1918.3 | E. White Alps | red-brown rock with very rare feld phenos, rare laminations; calcite | | | | |

| | Table 4. Sample Locations and Descriptions of Rosebud Volcanic Rocks | | | | | |
|---|---|---|---|---|---|---|
| | | | Lac* | | Brady | |
| Sample: | Location | Description | Map | Name | Map unit | Comments |
| **WR31** | low on N. side Rosebud Canyon | brown platy | Tcf | sill; Choc | Tri | RB-9: "vitric trachyte" with weak trachytic texture; weak clay. Moore's a |
| NWRA-2601 | NW. of USMM212 (N. Equinox) | platy rock with very rare feld phenos in pilotaxitic matrix; bleaching along laminations | | | | |
| 446:1907.2 | E. White Alps | same as 1918.3 but well laminated and with weak arg. & pyrite; calcite | | | | |
| **NWRA-2602** | NW. of USMM212 (N. Equinox) | pink-grey rock with very rare feld phenos in felted microlite matrix; tr. clay | | | | |
| WR161 | top of W. end South Ridge, E. of shaft on topo map | ? | ? | ? | Td | RB-7: f.g. crystal tuff; san <1 mm, deeply embayed qtz; completely serici |
| 446:1901.8 | E. White Alps | same as 1918.3 but well laminated and with moderate arg. & pyrite | | | | |
| | | | | | | |
| **"Chocolate"** | | | | | | |
| WR5 | N. of Juniper Canyon, S. side hill 1884 | trachytic porphyry | Tcf | Choc | Tc | Moore's rhyodacite flow, "Tci" |
| WR15 | N. of Juniper Canyon, S. side hill 1884 | grey purple felsite por | Tcf | Choc | Tc or Tbf | Moore's rhyodacite flow, "Tci" |
| WR74 | Schoolbus Canyon | ? | Tdt | ? | Tc | |
| WR55 | W. side Schoolbus Canyon | flow-banded | Tdt | ? | Ta | Moore's "Tbe" |
| WR72 | W. of Rosebud Peak | ? | Tdt | ? | Tc | |
| WR50 | W. side draw NW. of waste pile | tuff | Tcf | ? | Tri in Tc? | Moore's Tct |
| **WR53** | E. side Schoolbus Canyon | flow-banded tuff | Tcf | Choc | Tc | |
| WR39 | S. of Rosebud Canyon, N. side of top of hill 1947m | flow-banded crystal-lit | Tcf | Choc | off map (projects to "Tcw") | |
| WR51 | S. of Rosebud Peak, N. of RBW-17, on slope | tuff | Tcf | ? | Tcv | Moore's Tct |
| WR3 | top of Dozer Hill | tuff | Tdt | Dozer | Tc | hand sample is pale grey with clay-altered mafic phenos and paler altera |
| | | | | | | |
| **Feldspar-phyric rocks with mmb and locally rare quartz phenocrysts** | | | | | | |
| 443:1564.0 | Dreamland | pseudobreccia with rare feld phenos and mmb, irregular banding; calcite, weak green clay | | | | |
| 445:1864.3 | Brown Palace | brecciated rock with 3% feld phenos <2 mm, 1% mmb, v. rare qtz; calcite | | | | |
| **444:1597.2** | Dreamland | 5% feldspar phenos <3 mm, <1% mmb, rare mafic phenos, v. rare qtz; calcite | | | | |
| 445:1906.0 | Brown Palace | same as 445:1864.3; calcite | | | | |
| 445:1853.4 | Brown Palace | same as 445:1864.3 but weak to mod. arg & pyrite | | | | |
| 445:1777.0 | Brown Palace | same as 445:1864.3 but strong arg & minor pyrite | | | | |
| 445:1793.6 | Brown Palace | same as 445:1864.3 but mod. to strong arg & pyrite; hard brown veinlets | | | | |
| | | | | | | |
| **Porphyritic "Chocolate" or "intrusions"** | | | | | | |
| WR4 | knoll S. of USMM212 (N. Equinox) | quartz latite | Til | intrusion | Ta | Moore's Ti |
| WR61 | NW. of Mother Lode shaft | ? | Til | intrusion? | Ta? | probably part of "gorilla" intrusion |
| WR21 | E. side Rosebud Peak | aphanitic intrusion | Til | Choc | Tc, proba | probably from the brown porphyritic outcrop like "gorilla" |
| WR47 | NW. end of top of Big Chocolate Hill | grey crystal | Tcf | Choc | Tc | RB-11: nearly fresh plag (An25) phenos, biotite phenos; minor clay, hem |
| | | | | | | |
| **West Kamma Peak intrusions** | | | | | | |
| WR38 | S. of Rosebud Canyon, on W. Kamma Peak (1931m) | blue-grey felsite | Til or | Choc | Ta | Moore's platy rhyolite plug, "Ti?" |
| WR37 | S. of Rosebud Canyon, NW. of W. Kamma Peak (19 | brown intrusive felsite | Tir or | Choc | Ta | Moore's Ti |
| | | | | | | |
| **Lantern intrusions** | | | | | | |
| **WR40** | 3 km S. of Rosebud Canyon, on hill 1753m, Lantern | light green | Tir | intrusion | off map | |
| WR44 | 4.3 km S. of Rosebud Canyon, on knob NW of 1746m, W. flank of range | | | | | |
| WR41 | 3 km S. of Rosebud Canyon, on hill 1753m, Lantern | ? | Tir | ? | off map | |
| | | | | | | |
| **Coarsely porphyritic (K-spar+plag) rocks** | | | | | | |
| 446:2942.9 | E. White Alps | same as 446:2901.1 but mod. green clay and calcite, rare pyrite | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Table 4. Sample Locations and Descriptions of Rosebud Volcanic Rocks** | | | | | |
| | | | Lac* | | Brady | |
| Sample: | Location | Description | Map | Name | Map unit | Comments |
| 444:1935.7 | Dreamland | 4% feldspar phenos up to 10 mm; calcite, possibly v. weak arg. | | | | |
| 444:1920.4 | Dreamland | same as 444:1935.7 but w. arg; calcite | | | | |
| **444:1727.4** | Dreamland | 5% feldspar phenos up to 10 mm; calcite, v. weak arg.?, tr. green clay in fractures | | | | |
| 444:1717.8 | Dreamland | 2% sanidine and plag phenos up to 8 mm in felted microlite matrix; calcite, weak arg. & some green phenos | | | | |
| 446:2901.1 | E. White Alps | 2% white and 3% green feldspar phenos up to 10 mm in felted matrix; calcite, weak green clay | | | | |
| | | | | | | |
| **Plagioclase(>10%)-phyric rock with common hornblende** | | | | | | |
| 422.1:1959.6 | Lucky Boy | 20% zoned plag .5-2 mm, 5% hornblende? phenos <1 mm; calcite, weak arg. (feldspar) and green clay (hbl) | | | | |
| 446:2658.3 | E. White Alps | 25% plag up to 3 mm, 15% hornblende? phenos <3 mm in pilotaxitic matrix; calcite, weak arg. & green clay; very rare amygdales | | | | |
| | | | | | | |
| **Plagioclase(>10%)-phyric rock with common biotite and minor hornblende** | | | | | | |
| 422.1:1985.1 | Lucky Boy | 20% inconspicuous plag <2 mm, 3% biotite and 1% hbl <1 mm; calcite, weak arg. & green clay | | | | |
| | | | | | | |
| **Microhornblende-rich rocks (amygdaloidal)** | | | | | | |
| 422:2318.1 | Lucky Boy | 10% hbl microphenos in pilotaxitic groundmass, 10% amygdales; calcite, tr. green clay | | | | |
| 422:2141.6 | Lucky Boy | 3% hbl microphenos in pilotaxitic groundmass, 15% amygdales; calcite, weak green clay | | | | |
| | | | | | | |
| **Dreamland vitric-lithic lapilli-ash tuff** | | | | | | |
| 424:2009.6 | Dreamland | devitrified vitric-lithic lapilli-ash tuff with <3% volcanic and phyllite clasts and rare, green glass lapilli | | | | |
| | | | | | | |
| **Barrel Springs rocks** | | | | | | |
| WR166 | S. edge of ridge S. of 1481m | white tuff | Tbs | ? | off map | |
| WR165 | W. side of hill W. of 1481m | siliceous tuff | Tbs | ? | off map | |
| | | | | | | |
| **Wildrose Canyon vitrophyre** | | | | | | |
| WR19 | S. of W. end of Wildrose Canyon | vitrophyre, perlitic cra | Tdt | S. Ridge tuff | | |
| | | | | | | |
| **Other felsic rocks** | | | | | | |
| WR30 | N. of Jungo Rd junction with Rosebud mine road | intrusion | Ti | ? | off map | |
| WR52 | E. side of Schoolbus Canyon | black vitrophyre | Tcf | Choc | Tc? | Moore's Chocolate-like rhyolite, "Tbc" |
| WR23 | E. of Crofoot-Lewis, W. edge of range NW. of 1778m | aphanitic | Tia? | young flow? | off map | |
| WR65 | S. of Rosebud Canyon, W. of W. Kamma Peak (1931 | white tuff | Tbs | ? | Tos | probably in southward continuation of "Dozer" |
| | | | | | | |
| **Andesite and Basalt** | | | | | | |
| SuK-97-3 | SE. of Jungo Rd junction with Rosebud mine road | basalt with plag phenos up to 3 cm and olivine and augite in groundmass | | | | |
| SK-98-1 | E. of Rosebud mine road | olivine-phyric basalt with quartz xenocrysts | | | | |
| F-98-1 | W. of Rosebud mine road, black hogback | seriate basalt, dominantly plagioclase and augite | | | | |
| WR29 | W. of Rosebud mine road, black hogback | ? | Tb | young basalt | off map | same unit near F-98-1 |
| WR8 | S. of jct at W. end Rosebud Canyon | basalt | Tia | intrusion? | Tos | Moore's basalt intrusion |
| WR33 | W. end of Rosebud Canyon, N. of road | andesite | Tia | intrusion | ? | |
| WR28 | E. side range N of Wildrose Canyon and of 1579m | grey clast? | Tia | "huh?" | Tbrx? | |
| | | | | | | |
| Lac* - descriptions are from notes by S. Maynard or G. Massingill; map units are from Massingill's map; | | | | | | "RB" samples were collected near indicated sample by Brady; |
| | names are either Maynard's (listed first) or Massingill's (listed second); | | | | | thin sections were examined by other consultants |
| | most samples were probably collected by Massingill (<WR80) but Maynard compiled whole-rock data | | | | | |