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PRELIMINARY SCIENTIFIC RESULTS OF THE CREEDE CALDERA CONTINENTAL SCIENTIFIC DRILLING PROGRAM

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PHENOCRYST COMPOSITIONS OF LATE ASH-FLOW TUFFS FROM THE CENTRAL SAN JUAN CALDERA CLUSTER: RESULTS FROM CREEDE DRILL-HOLE SAMPLES AND IMPLICATIONS FOR REGIONAL STRATIGRAPHY

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ABSTRACT

Compositions of phenocrysts in ash-flow tuffs have proven useful for stratigraphic correlations among tuffs of similar mineralogy, distribution, and outcrop appearance. In addition, phenocryst compositions provide information on magmatic and eruptive processes. Compositions of sanidine and hornblende phenocrysts have been determined by electron microprobe for surface and drill-core samples of tuffs associated with the Creede and San Luis calderas in the Oligocene San Juan volcanic field, including the Snowshoe Mountain and Nelson Mountain Tuffs. Overall, average Or (orthoclase) content of sanidine is lower for the Nelson Mountain Tuff (either outflow, Or_{64}, or intracaldera, Or_{65}) than for the Snowshoe Mountain Tuff (Or_{70}). Drill-core samples of tuff from deep in the Creede caldera moat resemble Snowshoe Mountain Tuff in general petrography and in sanidine composition (Or_{71}). Drill-core samples of welded-tuff cobbles from a stream channel (Creede Formation, Bulldog Mountain area) eroded into the north wall of the Creede caldera appear to be Nelson Mountain Tuff, providing regionally critical evidence that this tuff unit and the San Luis caldera predate the Snowshoe Mountain Tuff and Creede caldera. Compositions of sparse hornblende phenocrysts are consistent with the sanidine data for most Snowshoe and Nelson Mountain samples; some compositionally anomalous hornblende may be xenocrystic. At lowest stratigraphic levels (early erupted rhyolite), Nelson Mountain sanidines have relatively uniform low-K compositions (Or_{62-64}), but at higher levels (later erupted dacite) sanidine compositions become more potassic and more variable (to Or_{70}), indicating eruption from a strongly compositionally zoned magma body. Backscatter electron images of some large unbroken sanidine crystals document oscillatory zoned interiors, overgrown by barium and strontium-rich rims, that suggest late influx of mafic alkalic magma into the Nelson Mountain magma chamber.

INTRODUCTION

Andesitic to rhyolitic tuffs and lavas of the Oligocene San Juan volcanic field, along with associated epithermal ores, have been recurrently studied for more than 100 years. While much has been learned about the evolution of several complex caldera clusters from which at least 22 major ash-flow sheets (100-3,000 km^3) were erupted at 30-26 Ma (Steven and Lipman, 1976; Lipman, 1989), major stratigraphic and volcanologic problems remain unresolved despite intensive recent studies in support of the Creede Drilling Project. These efforts include application of modern concepts of explosive volcanic processes, minor-element and isotopic rock chemistry, microprobe analysis of phenocryst compositions, paleomagnetic pole determinations, $^{40}Ar/^{39}Ar$ isotopic dating, and potential-field and electrical geophysical surveys.

The eruptive history for most major tuff sheets of the central San Juan Mountains is well understood (Table 1), but stratigraphic relations among the youngest tuffs, erupted from the Creede caldera and from the San Luis caldera complex, have remained enigmatic (Ratte and Steven, 1967; Lipman and others, 1989; Lanphere, 1988). The major unresolved problem involves the relative ages of Snowshoe Mountain Tuff from the Creede caldera and tuffs from the San Luis caldera complex (Rat Creek, Cebolla Creek, and Nelson Mountain Tuffs), which are nowhere exposed in depositional sequence, with the possible exception of Palmer Mesa (Fig. 1, loc. N6). There, small erosional remnants of tuff, previously interpreted as outflow Snowshoe Mountain (Steven and others, 1974), clearly overlie outflow Nelson Mountain Tuff. Previous interpretations have inferred that the outflow Snowshoe Mountain Tuff, which is only weakly welded where preserved, was readily eroded from most areas where it spread above the Nelson Mountain Tuff (Steven and Lipman, 1976). In contrast, initial $^{40}Ar/^{39}Ar$ dating of central San Juan volcanic units has suggested that the Nelson Mountain Tuff was about 0.6 m.y. be younger than the Snowshoe Mountain (Lanphere, 1988). Additional dating has disclosed some currently incompletely understood complexities among mineral ages for the Nelson Mountain Tuff, which vary by about 1 m.y. (5-10 times analytical precision), or in field correlations among different areas currently mapped as this unit. Field and lab studies are continuing.

Meanwhile, the Creede drilling project has provided additional constraints on these regional volcanologic problems. Prior to the drilling effort, one hypothesis to account for the lack of identified surface contact relations between Snowshoe and Nelson Mountain Tuffs was that the Nelson Mountain might be present at depth in the moat of the Creede caldera (interlayered with, or underlying the Creede Formation). Preliminary paleomagnetic data (J. Rosenbaum and R. Reynolds, unpubl. data, 1993) also raised the possibility that upper parts of the Snowshoe Mountain Tuff on the intracaldera resurgent dome and the tuff encountered at the bottom of the Creede scientific drill holes might be Nelson Mountain Tuff. Accordingly, we have studied the mineral chemistry of the ash-flow unit penetrated at depth in the Creede scientific drill holes and potential correlative units in surface exposures in order to characterize the drill-hole samples, to test correlations with units known at the surface, and to attempt to resolve the continuing uncertainties in correlations among the major young tuff units in the central San Juan Mountains.

STRATIGRAPHIC AND PETROLOGIC FRAMEWORK

The San Luis caldera complex was the source of three sizeable ash-flow deposits; in sequence, these are the Rat Creek, Cebolla Creek, and Nelson Mountain Tuffs (Lipman and others, 1989). Rat Creek Tuff is exposed as an outflow tuff sheet, mainly on the south side of the San Luis caldera complex in the vicinity of the Creede mining district; it is compositionally zoned from phenocryst-poor rhyolite (sanidine, plagioclase, biotite) that is mostly weakly welded upward into more phenocryst-rich dacite (plagioclase, biotite, augite, sanidine).

The tuff of Cebolla Creek is exposed discontinuously on all sides of the San Luis caldera complex, and locally as intracaldera tuff along the southeast caldera wall; this unit appears to have been widely eroded before eruption of the overlying Nelson Mountain Tuff. The tuff of Cebolla Creek consists dominantly of phenocryst-rich dacite, characterized by abundant hornblende phenocrysts and lacking sanidine.

Nelson Mountain Tuff is the most voluminous and widespread outflow tuff erupted from the San Luis caldera complex and is preserved as a distinctive mesa-capping unit on all sides of the caldera. Like Rat Creek Tuff, the Nelson Mountain is compositionally zoned from weakly welded phenocryst-poor rhyolite (70-73% SiO_2) upward into densely welded transitional rhyolite-dacite and local dacite (65-70% SiO_2). Phenocryst contents and overall appearance of the Nelson Mountain Tuff can be similar to the Rat Creek, but the two units are usually present in stratigraphic sequence, and are also distinguishable by paleomagnetic inclination (low for the Rat Creek, variably steep for the Nelson: J. Rosenbaum and R. Reynolds, written commun. 1991). The thick fill of dacitic tuff within the San Luis caldera generally has been interpreted as intracaldera Nelson Mountain (Steven and Lipman, 1976; Lipman and others, 1989).

Snowshoe Mountain Tuff is exposed as thick intracaldera tuff on the Snowshoe Mountain resurgent dome and as local erosional remnants of outflow tuff, especially to the southeast and southwest of the Creede caldera (Steven and others, 1974; Lipman, 1975; Steven and Lipman, 1976). The Snowshoe is a phenocryst-rich mafic dacite (61-67% SiO_2; abundant plagioclase, biotite, augite, and sparse quartz, biotite, sanidine, and hornblende).

The Snowshoe Mountain Tuff overlaps in bulk-chemical and modal compositions with dacitic parts of the Nelson Mountain Tuff, and these units can be difficult to distinguish reliably in the field. Mineral chemical studies hold promise for distinguishing them. Previous X-ray and microprobe studies have documented generally higher potassium (Or) contents for sanidine in the Snowshoe Mountain than in Nelson Mountain Tuff (Lipman, 1975 and unpubl.; Sawyer and others, 1987 and unpubl.; Riciputi, 1991). Mineral-chemical data for phenocrysts from other central San Juan tuff units show wide inter-tuff variability in sanidine and hornblende compositions, but much less variation for biotite and augite (Lipman, 1975; Whitney and Stormer, 1985; Whitney and others, 1988; Webber, 1988; Riciputi, 1991; D.A. Sawyer, written commun., 1993). Accordingly, in this study we have focused on determining compositions of sanidine and hornblende phenocrysts.

METHODS

Mineral compositions of 165 sanidine crystals from 26 samples, and 21 hornblendes from 8 samples, were determined using the JEOL 8900 microprobe at the U.S. Geological Survey laboratory in Menlo Park (Appendices 1, 2). The acceleration voltage was 15kV for all analyses. Sanidines were analyzed using a beam current (read at the cup) of 15nA and a 10 micron diameter beam; hornblendes were analyzed using a 20nA current and a 5 micron beam. Each grain was analyzed at 1-5 points, depending on size and apparent zonation visible from backscatter electron images. For each sample 3-11 grains were analyzed, the number of grains depending on the abundance of that phase in the thin section. Sanidine crystals are only sparsely present in many samples, especially in phenocryst-rich dacite. We analyzed at least 5 grains per phase in each thin section where possible, in order to evaluate intra-sample compositional variation.

Analytical error is at most 2% of the amount present for potassium and other major elements, and 10% for barium and other minor elements, based on repeat analyses of the control standard Orthoclase-1a. Strontium and magnesium were consistently at or below detection limits. Control standards were analyzed frequently during each probe session, commonly before and after analyzing each thin section, to confirm instrument stability.

Intra-sample variation:

In any bulk-tuff sample, phenocryst grains derived from a compositionally zoned or otherwise variable magma chamber are subject to mechanical mixing during eruption and emplacement and to contamination by xenocrysts derived from disaggregation of lithic fragments. The sanidine and hornblende grains analyzed in this study are 50-500 microns in length (typically 100-300 microns), mostly occurring as broken fragments of what must have been larger crystals before eruption and emplacement. Most of the tuff samples, especially from late-erupted upper parts of tuff sheets, show sizeable variations in phenocryst compositions that likely result from such mechanical mixing. Such variability complicates rigorous interpretation of magmatic compositions from single samples, but it also provides a more synoptic perspective on overall compositional ranges within a large-volume magmatic system than mineral data from a small number of separate pumice samples. More detailed microprobe studies of individual pumices lenses that are stratigraphically well controlled would be a logical next step in studying the compositional complexities of the ash-flow units from the central San Juan Mountains.

Intra-crystal zonation:

Because most of the sanidine grains are fragments, coherent compositional zonation is difficult to determine within crystals. Even where microprobe analyses at points in the core and margin of a grain document varying compositions, the broken shapes of the crystals make the magmatic zonation difficult to interpret. Backscatter electron images for most such grains show only irregular patchy compositional variations, because of the random orientation and small size of crystal fragments. Both Nelson and Snowshoe Mountain samples contain scattered large sanidine crystals, however, for which backscattered electron images show coherent oscillatory zonation patterns of fluctuating potassium and barium (Fig. 2). The image in Figure 2A shows intricate oscillatory zoning in a typical sanidine crystal from lowermost intracaldera Nelson Mountain Tuff (sample I7); image B in Figure 2 from the same sample shows a magmatic overgrowth of feldspar rich in barium, strontium, and iron. Phenocryst A and the interior of phenocryst B have typical contents of barium, strontium and iron for the Nelson Mountain Tuff (Table 3), but the rim of crystal B is high in these elements, normalizing to 6.4 percent celsian. The rim of crystal B has the highest barium + strontium content of any sanidine analysis made in the present study (Appendix 1). Such rim overgrowths suggest late mixing with a mafic alkalic magma, as previously interpreted for similar features in the Carpenter Ridge Tuff of the San Juan field by Dorais and others (1991) and for the Bishop Tuff (California) and Bandelier Tuff (New Mexico) by Hervig and Dunbar (1992). Detailed study of sanidine zoning in the tuffs from the central San Juan caldera cluster could provide key information on magmatic processes which may be common to large silicic magma chambers.

COMPOSITIONS OF SANIDINE PHENOCRYSTS

Sanidine phenocrysts were analyzed from the ash-flow tuff encountered deep in the Creede project drill holes and from key surface localities for the major late ash-flow sheets in the central San Juan region (Table 4, Appendix 1), except for the tuff of Cebolla Creek, which lacks sanidine. Orthoclase (Or) and Celsian (Cn) compositions are listed in the discussion below first as sample averages, then as ranges among all grains analyzed. A summary diagram of Or + Cn versus Albite (Ab) for the samples discussed below shows the largely distinct but partly overlapping compositional fields for the Nelson Mountain and Snowshoe Mountain Tuffs (Fig. 3).

Rat Creek Tuff

A single sample of transitional rhyolite-dacite, collected from the upper welded part of this tuff at geographic Nelson Mountain, contains relatively sodic sanidine phenocrysts ($Or_{62.0(59.6-66.7)}$) that are compositionally similar to previous X-ray diffraction compositional determinations on five other samples (Lipman, 1975 and unpubl.). Sparse grains of more Or-rich sanidine (Fig. 4A, Appendix 1) may have been derived from intermixed more dacitic Rat Creek magma, by analogy with data from other tuff units as discussed below.

Nelson Mountain Tuff

All analyzed samples analyzed are welded low-silica rhyolite or dacite. Most samples are from $^{40}Ar/^{39}Ar$ age or paleomagnetic sample sites (Lanphere, 1988 and unpubl.; J. Rosenbaum and R. Reynolds, unpubl.).

Outflow tuff:

Six samples from outflow Nelson Mountain Tuff, collected to provide coverage of the east-west extent of this unit (Fig. 1) and keyed to problematic $^{40}Ar/^{39}Ar$ age localities, contain sanidines that are variable in Or and Cn contents (Fig. 4A; Tables

1, 2). The average Or content and range for the outflow samples ($Or_{63.9(58.9-70.5)}$), excluding a single anomalous grain at $Or_{50.5}$, are similar to the Rat Creek sample and also to data published by others for the Carpenter Ridge Tuff (Table 1). Samples from low in the Nelson Mountain Tuff (early erupted) in the ash-flow sheet tend to be more uniform in composition and less Or rich than stratigraphically higher late-erupted tuff. The most potassic sanidines and the greatest variability among analyzed samples are from the uppermost exposure of this tuff unit at Palmer Mesa (N6: $Or_{65.4(61.2-69.7)}$) and on the southeast side of geographic Nelson Mountain (N1: $Or_{66.8(63.9-70.5)}$). All other outflow samples have lower maximum and average Or contents.

Intracaldera tuff:

Overall, sanidine crystals from the intracaldera Nelson Mountain Tuff have a range of Or contents (Fig. 4B) similar to outflow samples ($Or_{58.6-73.0}$ intracaldera, *vs* $Or_{58.9-70.5}$ outflow), but the average Or content is somewhat higher ($Or_{65.3}$, *vs* $Or_{63.9}$ for outflow), and the intra-sample variability is greater (s.d. 4.4, *vs* 2.6 for outflow). The Or values are most potassic and variability is greatest for sanidine from high in intracaldera Nelson Mountain sections.

A transitional rhyolite-dacite from low in the caldera fill (I7) has relatively sodic sanidine compositions with a narrow compositional range ($Or_{62.9(58.6-64.9)}$), similar to those in the Rat Creek Tuff. An overlying welded dacite, still low in the section (I6), has a higher average Or content and a wider range ($Or_{67.4(58.6-73.0)}$). Another welded dacite from mid levels of the intracaldera tuff (I5) also has highly variable sanidine compositions ($Or_{63.4(61.0-70.1)}$). Three geographically dispersed samples from high in the intracaldera tuff (I2-I4) have similarly potassic average compositions ($Or_{68.2-68.4}$), but widely varying compositional ranges. In contrast, sanidine from a separate late-erupted dacitic intracaldera tuff sheet of Nelson-like petrography (I1), which overlies lava flows within the caldera, is relatively sodic and uniform in composition ($Or_{63.8(62.9-64.8)}$), indicating eruption from a different magmatic source than late dacite of the main Nelson tuff sheet.

The large variation in sanidine compositions for late-erupted Nelson Mountain Tuff suggests that the eruption tapped a fractionated magma body (zoned rhyolite to dacite) progressively downward into more mafic levels (Hildreth, 1981; Trial and others, 1992), perhaps also incorporating some xenocrystic material from landslides, contamination in the conduit during eruption, and assimilation from walls of the magma chamber. The most abundant xenoliths in the Nelson Mountain Tuff are sanidine-free andesitic lava, probably from the precaldera Conejos Formation, but the San Luis caldera also impinges on northern parts of the La Garita and Bachelor calderas, and sparse sanidine crystals derived from disaggregated fragments of intracaldera Fish Canyon or Carpenter Ridge Tuffs would be difficult to distinguish in composition from those cognate to the Nelson Mountain.

Snowshoe Mountain Tuff

Surface samples of the Snowshoe Mountain Tuff have higher and less variable sanidine Or contents (Fig. 4C) than any other samples analyzed in this study, except for probably correlative tuff samples from the Creede scientific drill holes (Table 2, Fig. 8). All analyzed Snowshoe samples are crystal-rich dacite, similar in bulk chemistry and mineralogy to late-erupted Nelson Mountain Tuff. Overall, outflow Snowshoe samples are indistinguishable from intracaldera tuffs, based on sanidine chemistry, although compositions appear to vary as a function of stratigraphic level. Taken together, samples of outflow and intracaldera Snowshoe Mountain Tuff have more potassic average sanidine compositions ($Or_{69.7(63.9-73.3)}$) than any other tuff sheet in the central San Juans except the Fish Canyon Tuff (Table 1; Whitney and Stormer, 1985).

Outflow tuff:

Outflow samples of the Snowshoe Mountain Tuff (S3-S6) are partly welded tan to gray crystal-rich dacite. The two samples from high in Snowshoe sections (S3, S4) contain slightly more potassic average sanidine compositions ($Or_{68.9-71.2}$) than two collected from low in the tuff sheet (S5, S6: $Or_{68.5-68.9}$). Sanidine compositions for outflow Snowshoe Mountain Tuff are all more potassic than for outflow Nelson Mountain Tuff, although there is near overlap in sanidine composition with late-erupted intracaldera Nelson Mountain samples (Fig. 3).

Intracaldera tuff:

The two analyzed surface samples of intracaldera Snowshoe Mountain Tuff (S1, S2) are both partly welded gray dacitic tuff from near the top of the unit on the west flank of the resurgent dome. Sample S1 from just below a depositional contact with overlying moat sediments of the Creede Formation has the most potassic average sanidine composition ($Or_{71.5}$) of any young tuff sample analyzed from the central San Juan region. Sample S2, from a paleomagnetic site near the top of the Snowshoe, also has a more potassic average sanidine composition ($Or_{70.0}$) than any Nelson Mountain sample, but is similar to the most potassic late-erupted outflow of the Snowshoe Mountain Tuff. The two intracaldera samples together confirm and further extend the suggested trend of increasingly potassic sanidine compositions during the course of the Snowshoe Mountain eruptions.

Tuff from the Creede drill hole

Sanidines were analyzed from three samples of the weakly welded phenocryst-rich ash-flow tuff penetrated deep in Creede research drill hole 2 (airport hole): (1) bottom of the hole at a depth of 2323 feet (sample D1), (2) near the top of the massive tuff unit at a depth of 2168 feet (D2), and (3) matrix tuff and an enclosed lava clast from an overlying lithic-rich tuff or tuffaceous debris flow at a depth of 2043 feet (D3). Thin-section petrography and mineral chemistry confirm that these tuffs are from near the top of the intracaldera Snowshoe Mountain Tuff, rather than the tentatively proposed alternative of Nelson Mountain Tuff ponded in the moat of the Creede caldera. Sanidine from the two samples of massive tuff penetrated at the bottom of the drill hole is more potassic and more uniform in average composition ($Or_{71.2-71.4}$) than any samples of Nelson Mountain Tuff (Fig. 4D), but is closely similar to the two surface samples of intracaldera Snowshoe Mountain Tuff on the adjacent flank of the resurgent dome.

The third sample (D3), a lithic-rich weakly or nonwelded tuff, may be the product of a late small-volume explosive ash eruption or a tuffaceous mudflow deposit derived from the caldera walls. The dominant clasts are intracaldera Carpenter Ridge Tuff and dacitic lava. Compositions of sanidine crystals from the tuffaceous matrix are bimodal, some with Snowshoe Mountain compositions ($Or_{71.1-71.2}$), and others more sodic ($Or_{59.8.-63.4}$) that may represent disaggregated phenocrysts from clasts of the dacite lava or Carpenter Ridge Tuff. Despite the range in sanidine compositions, this tuff unit is an unlikely candidate for Nelson Mountain Tuff because (1) it is nonwelded in contrast with the typical densely welded outflow Nelson, (2) it is much more lithic rich than any outflow Nelson, and (3) the sanidine compositional variation may be bimodal (data from analyses of only four grains) rather than continuous as in the analyzed samples of Nelson Mountain Tuff (Fig. 4A).

Caldera-wall channel deposits (Creede Formation near Bulldog Mountain)

Conglomerates in a stream channel on the north wall of the Creede caldera, which represent an alluvial-fan facies of the moat-filling Creede Formation, contain abundant welded tuff cobbles that provide important information on paleogeology at the time of formation of the Creede caldera. Core samples from exploration drilling near Bulldog Mountain contain abundant cobbles of distinctive Wason Park Tuff, which forms bedrock for the local steam channel, and also sparse cobbles of a more phenocryst-rich welded tuff which megascopically resembles Rat Creek or Nelson Mountain Tuff. Two representative cobbles of the phenocryst-rich tuff (B1, B2) contain relatively sodic sanidine compositions ($Or_{61.6-63.0}$) that are plausible for Rat Creek or Nelson Mountain Tuff but cannot be from the Snowshoe Mountain Tuff (Fig. 4E). These cobbles are most likely Nelson Mountain rather than Rat Creek Tuff, based on an apparent southwestward wedgeout of the Rat Creek north of the Creede caldera wall and short of the headward projection of the Creede channel. These cobbles thus demonstrate the prior existence of outflow Nelson Mountain Tuff (or Rat Creek Tuff) in the area of the Creede caldera prior to its collapse and erosional enlargement.

Tuff at McDonough Reservoir

A partly welded gray dacitic tuff, from near McDonough Reservoir north of the area depicted in Fig. 1, resembles Snowshoe Mountain Tuff in outcrop appearance and petrography; reconnaissance mapping seemingly requires that this unit is younger than the main outflow sheet of Nelson Mountain Tuff. The tuff at McDonough Reservoir has highly variable sanidine compositions ($Or_{65.3(51.4-71.2)}$)

that almost certainly reflect mechanically admixed xenolithic material (Fig. 4F). The tuff at McDonough Reservoir thus could be either late-erupted Nelson Mountain Tuff characterized by compositionally highly variable sanidine, or distal outflow Snowshoe Mountain Tuff with a large component of xenocrystic sanidine. Without further study of pumice compositions, no firm stratigraphic correlation can be made.

COMPOSITIONS OF HORNBLENDE PHENOCRYSTS

Prior mineral chemistry studies have shown that hornblende is the only silicate phenocryst phase in addition to feldspars that varies substantially in composition among ash-flow sheets erupted from the central San Juan caldera cluster (e.g., Webber, 1988; Riciputi, 1991). Except for the Fish Canyon Tuff, hornblende phenocrysts are sparse in these units, occurring mainly in late-erupted dacite in which the dominant mafic silicates are biotite and augite that show little compositional variability. Interpretation of compositional variations among the sparse hornblende phenocrysts is further complicated by the potential for xenocrystic amphibole derived from the thick sequence of precaldera intermediate-composition lavas (Conejos Formation) that underlie the San Juan ash-flow sequence and constitute the dominant lithic fragments present in the tuffs. Riciputi (1991) showed that compositions of hornblende phenocrysts in central San Juan ash-flow sheets plot in two discrete fields: (1) Fish Canyon and Snowshoe Mountain Tuffs, and (2) Blue Creek and Wason Park Tuffs (Fig. 5). These groups correspond to distinctions among major-element bulk-tuff chemistry that suggest that the ash-flow magmas of the central San Juans represent cyclic evolution of magmas, and that the Fish Canyon and Snowshoe Mountain Tuffs fractionated at deeper crustal levels than the Carpenter Ridge, Blue Creek, and Wason Park Tuffs (Lipman and others, 1978; Riciputi, 1991).

Hornblende analyses from eight samples in this study (Table 5, Appendix 2) plot in the fields of Riciputi (1991), corroborating that samples S1, S2, S3, and S5 are likely Snowshoe Mountain Tuff (Fig. 9). The new hornblende analyses of Snowshoe Mountain Tuff are compositionally similar to previously analyzed hornblende phenocrysts from the Fish Canyon and Snowshoe Mountain Tuffs. They have relatively low Al, Ti, and Na, and high Mn contents. In contrast, hornblendes from one sample of Nelson Mountain Tuff (N1) and the Cebolla Creek sample (CC) plot in or near the field for Wason Park and Blue Creek Tuffs, which Riciputi (1991) interpreted as genetically related to the Nelson Mountain Tuff. Hornblende compositions for one sample from uppermost outflow Nelson Mountain Tuff (N6) plot in the same fields as Snowshoe Mountain Tuff, however, rather than with other Nelson Mountain analyses. This result could indicate admixed hornblende from xenoliths of Fish Canyon Tuff or dacitic lava flows, or could indicate that hornblende compositions in late-eruptions of dacitic Nelson Mountain Tuff converge with those characteristic of the Snowshoe Mountain Tuff. No hornblende is present in the Creede drill-hole samples studied by us and interpreted as uppermost intracaldera Snowshoe Mountain Tuff. Hornblende crystals from the tuff at McDonough Reservoir have widely variable compositions, as do the sanidines, that indicate mechanical syn-eruption/emplacement mixing of phenocrysts from differing sources.

DISCUSSION AND CONCLUSIONS

Petrographic studies and microprobe determinations of mineral compositions from surface and drill-hole samples of late ash-flow sheets erupted from the central San Juan caldera cluster help resolve several important regional stratigraphic problems, as well as constraining correlations with tuffs encountered at depth during the Creede scientific drilling project.

Phenocryst compositions indicate that the massive tuff from lower parts of drill hole 2 in the Creede caldera moat is the uppermost intracaldera Snowshoe Mountain Tuff, based on Or content and comparisons of sanidine phenocryst compositions with other tuffs and data from other workers. This tuff is closely similar to that exposed at the surface near Point of Rocks. It cannot be outflow Nelson Mountain Tuff that accumulated deep within the Creede caldera moat, an intriguing hypothesis permitted by preliminary paleomagnetic data. This tuff differs from outflow dacitic late-erupted Nelson Mountain Tuff in its more potassic average sanidine composition, lesser grain-to-grain variability within single samples, more abundant lithic fragments, and lesser welding.

Stratigraphic evidence, evaluated in relation to mineral compositional variations between and within ash-flow sheets, now strongly suggests that the Snowshoe Mountain Tuff is younger than the Nelson Mountain Tuff, despite recent $^{39}Ar/^{40}Ar$ age determinations that suggest the opposite age relation (Lanphere, 1988 and unpubl. data). In agreement with previously inferred age relations (Steven and Ratte, 1965; Steven and Lipman, 1976), Snowshoe Mountain Tuff appears to overlie Nelson Mountain Tuff in a few small isolated patches on Palmer Mesa. As the youngest central San Juan ash-flow unit, the outflow Snowshoe Mountain Tuff has been erosionally removed from Nelson-capped mesas and elsewhere in the region where not armored by overlying lava flows of Hinsdale Basalt. New evidence for this stratigraphic sequence is the identification of cobbles of Nelson Mountain Tuff in stream-channel conglomerates of the Creede Formation deposited along the north wall of the Creede caldera near Bulldog Mountain shortly after the caldera collapsed. Recognition of Nelson Mountain cobbles in the Creede Formation appears to require that the Nelson Mountain Tuff was present as a capping unit on the rim of the Creede caldera at the time of its subsidence. The cause of the inconsistencies between the stratigraphic relations and the argon age determinations remains a problem that is being studied further.

The Snowshoe Mountain Tuff, the most phenocyrst-rich and mafic tuff sheet erupted from the central San Juan cluster (62-66% SiO_2), contains the most Or-rich sanidine phenocrysts of any tuff sheet other than the even more phenocryst-rich Fish Canyon Tuff. The Or content of sanidine phenocrysts in the Nelson Mountain Tuff is related inversely to bulk-tuff silica content, increasing from about Or_{59} to Or_{73}, as bulk tuff compositions change from rhyolite to dacite (from about 72 to 64 percent SiO_2). In the outflow Nelson Mountain sheet (and to a lesser degree in the Snowshoe Mountain Tuff), Or content of sanidine increases upward in section (during the course of the eruption) as the bulk tuff becomes more mafic, more phenocryst rich, and more heterogeneous, documenting progressive tapping of more mafic deeper parts of a compositionally zoned magma chamber (Lipman, 1967; Hildreth, 1981; Trial and others, 1992). In the intracaldera Nelson Mountain Tuff, sanidine phenocrysts are more Or-rich and heterogeneous, indicating dominant ponding of the latest erupted material within the concurrently subsiding source caldera. The Nelson Mountain Tuff contains the largest variation in sanidine phenocryst composition documented to date within a single eruptive volcanic unit known to us. Detailed determination of compositional variability among individual pumice lenses would be a fruitful direction for further study of this intriguing relation.

At least some of the rare high-barium analyses ($>Cn_4$) for the Nelson Mountain Tuff (both outflow and intracaldera) occur as rim overgrowths on zoned sanidine crystals (Fig. 2). High celsian contents are associated with relatively sodic sanidines characteristic of the early-erupted rhyolitic Nelson Mountain Tuff; no similarly high-barium values have been obtained from the more potassic sanidine phenocrysts that occur high in both outflow and intracaldera Nelson Mountain sections or for any analyzed sanidine from the Snowshoe Mountain Tuff. The barium-rich rims on Nelson Mountain sanidines are comparable to sanidines (Cn_{4-17}) in late-erupted barium-rich mafic fiamme (up to 13,000 ppm Ba) that are sparsely present in upper parts of the outflow Carpenter Ridge Tuff (Lipman, 1975; Whitney and others, 1988; Riciputi, 1991). While no such fiamme have been recognized to date in the Nelson Mountain, the barium- and strontium-rich rim overgrowths suggest late mixing with less evolved alkalic magma, as suggested by Whitney and others (1988) and Riciputi (1991) for the Carpenter Ridge Tuff. Sanidine phenocrysts with Ba-rich rims have also been documented in the Bishop Tuff in California and the Bandelier Tuff in New Mexico (Hervig and Dunbar, 1992). Barium concentrates efficiently in sanidine crystallizing from a silicic melt, and partition coefficients up to six have been measured experimentally (Nash and Crecraft, 1985). Such data have been interpreted to indicate that Ba-rich melts have invaded large ash-flow magma chambers periodically, because a Ba-rich liquid cannot be generated by fractional crystallization if sanidine is a liquidus phase. More thorough study of sanidine compositions in the Nelson Mountain Tuff, especially for individual pumice clasts, could yield more rigorous controls on the magmatic and eruptive processes involved in emplacements of the late tuff sheets of the central San Juan region.

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TABLES

1. Summary data for ash-flow sheets of the central San Juan caldera cluster. Modified from Lipman and others (1989), with additional age information from Lanphere (unpublished data) and sanidine compositions from this study, Whitney and Stormer (1985), Whitney and others (1988), Webber (1988), and Riciputi (1991).

2. Average sanidine compositions for each sample, late ash-flow sheets of the central San Juan caldera cluster (sample locations shown on Fig. 1).

3. Individual point microprobe analyses for two zoned sanidine phenocrysts, intracaldera Nelson Mountain Tuff (sample I7)

4. Representative sanidine analyses

5. Representative hornblende analyses

FIGURES

1. Sample location map, central San Juan caldera cluster (from Lipman and others, 1989). Caldera margins are indicated by hachured lines; gray shading, intracaldera resurgent uplifts; cross pattern, early intermediate-composition volcanic rocks (precaldera); unpatterned, caldera-related ash-flow tuffs and lavas. Key to calderas: B, Bachelor; C. Creede; CP, Cochetopa Park; LG, La Garita; MH, Mount Hope; SL, San Luis; SR, South River. Sample locations marked by black squares, except for the two drill-core cites marked with large 'X'. One sample (tuff at McDonough Reservoir) is from site about 5 km north of map area.

2. Backscatter electron images of sanidine phenocrysts from intracaldera Nelson Mountain Tuff (sample I7). Locations of microprobe analyses (Table 3) shown by numbered dots. Lightest areas of crystals are higher in mean atomic number (less sodic, more potassic, and enriched in Ba, Sr, Fe) than dark areas.
   A. Intricate oscillatory zoning in phenocryst
   B. Barium-rich overgrowth on phenocryst

3. Average values of Or + Cn versus Ab, sanidine phenocrysts in late ash-flow sheets, central San Juan caldera cluster. Data from Table 1. The sanidine composition for a dacite clast from the Creede drill core (sample D4) is also plotted, but no average composition has been calculated or plotted for the bimodally variable sanidine crystals in the matrix tuff of sample D3.

4. Histograms of microprobe analyses for sanidine phenocrysts in late ash-flow sheets, central San Juan caldera cluster; plotted are all individual analyses for of each sanidine grain. Data are from Appendix 1.
   A. Outflow Nelson Mountain and Rat Creek Tuffs
   B. Intracaldera Nelson Mountain Tuff
   C. Snowshoe Mountain Tuff (surface exposures)
   D. Snowshoe Mountain Tuff, in Creede drill core
   E. Welded-tuff cobbles (Nelson Mountain Tuff?), drill-core samples of Creede Formation near Bulldog Mountain
   F. Tuff at McDonough Reservoir

5. Average compositions of hornblende phenocrysts, late ash-flow tuffs of the central San Juan caldera cluster. Composition fields from Riciputi (1991). Symbols: solid diamonds, Snowshoe Mountain Tuff; open diamonds, Nelson Mountain Tuff; open square, tuff of Cebolla Creek; open circle, tuff at McDonough Reservoir. Sample numbers correspond to Figure 1 and Table 2.

APPENDICES

1. Individual point analyses, sanidine phenocrysts: calculated cations and end-member compositions, with averaged standard deviations
2. Individual point analyses, hornblende phenocrysts: 2A, weight percent oxides; 2B, calculated cations based on 24 oxygens

Table 1. Ash-flow sheets of the central San Juan caldera cluster

Age (Ma)	Source	Ash-flow tuffs	Composition of tuffs	Or content of Sanidines Range	Or content of Sanidines avg&std dev	Cn content Range	Cn content avg&sd	Lava flows	Sediments	Intrusions
16-23	Basaltic shields (Hinsdale fm.)	—	—	—	—	—	—	Trachybasalt and Trachyandesite	—	Local dikes
26.0-27.1	San Luis caldera complex	Late tuff						Volc. of Baldy Cinco: Volc. of Stewart Peak;	Local moat fill	Late stocks and dikes; resurgent pluton
		Nelson Mtn. Tuff	Rhyolite-dacite (zoned)							
		Outflow	(73-65% SiO_2) dacite	59.8-70.5%	63.9%, sd 2.6	0.9-4.3%	2.1%, sd 0.8			
		Intracaldera	(70-63% SiO_2) dacite	58.6-73.0%	65.3%, sd 4.4	0.0-6.4%	2.3%, sd 1.1			
		Tuff of Cebolla Cr.	Dacite							
26.3-27.0		**Rat Creek Tuff**	Rhyo-dacite	59.6-63.1%	62.0%, sd 1.9	1.3-4.7%	2.3%, sd 1.1	Rhyolite of Mineral Mtn.; McKenzie Mtn.--Captive Inca flows and domes		—
26.7-27.1	Creede caldera	**Snowshoe Mtn. Tuff**	Dacite-andesite (zoned) pheno-rich (SiO_2 61-67%)	63.9-73.3%	69.7%, sd 1.7	0.5-3.9%	2.4%, sd 0.9	Fisher Quartz Latite	Creede Fm.	Local plugs and dikes
27.2	S. River caldera	**Wason Park Tuff**	Dacite	44.2-59.5%	55.3%, sd 3.7	1.3-3.4%	1.9%, sd 0.6	Lava of S. River Peak; Volc. of Table Mtn.	—	Local plugs and dikes
27.3	(Creede area)	**Tuff of Blue Creek**	Dacite	55.9-63.2%	60.1%, sd 2.3	2.97-4.1%	3.3%, sd 0.5	Local flows	—	—
27.4	Bachelor caldera	**Carpenter Ridge Tuff**	Rhyolite-dacite (zoned)	58.7-73.1%	63.7%, sd 3.0	0.9-5.0%	1.8%, sd 1.2	Lavas of McClelland Mtn.	Local moat fill	—
			mafic fiamme	45.0-57.1%	51.6%, sd 3.5	3.7-16.8%	8.8%, sd 0.4			
27.8	La Garita caldera	**Fish Canyon Tuff**	Dacite (unzoned)	72.2-76.4%	74.5%, sd 2.3	0.8-2.2%?	1.5%, sd 0.4	—	Local moat fill	—
28.4 or 28.2??	Mt. Hope caldera	**Masonic Park Tuff**	Dacite	no data						
30-35	Precaldera volcanoes	—	—	—	—	—	—	Early intermediate-composition lavas	Laharic breccias and conglomerates	—

Table 2. Average sanidine compositions

Map	Location	Sample name		# of grains analyzed	Or% range	mol % of endmember compositions Or%	Cn%	Or+Cn%	Alb%	An%	Fe cations	Al cations	Sr cations
		Rat Creek Tuff											
R		85L-29F		5	59.6-66.7	62.0	2.3	64.3	34.3	1.4	0.005	1.04	n.d.
		Nelson Mtn. Tuff (intracaldera)											
I1		85L-11	late tuff unit	6	62.9-64.8	63.8	2.2	66.0	32.9	1.1	0.005	1.02	0.003
I2		DAS87070		5	58.7-71.1	68.4	2.9	71.3	27.6	1.1	0.005	1.04	0.004
I3		DAS 89038		5	61.0-73.0	68.2	2.1	70.3	28.7	1.1	0.005	1.03	0.004
I4		85S-110		5	65.3-70.9	68.4	2.5	70.9	28.2	0.9	0.004	1.03	n.d.
I5		DAS87042		5	61.0-70.1	63.4	2.9	66.3	32.6	1.2	0.005	1.03	0.005
I6		DAS88011		5	62.8-73.0	67.4	1.1	68.5	30.3	1.3	0.005	1.14	0.002
I7		DAS87063		9	58.6-64.9	62.9	2.4	65.2	33.6	1.2	0.005	1.04	0.003
		Nelson Mtn. Tuff (outflow)											
N1		C5-6-14		6	63.9-70.5	66.8	1.6	68.4	30.4	1.1	0.005	1.00	n.d.
N2		85L-29C	mineral separate	10	60.3-65.3	62.3	2.3	64.6	34.2	1.2	0.005	1.03	n.d.
N3		C5-18-3		6	59.8-63.8	62.5	2.5	65.0	34.0	1.3	0.005	1.04	n.d.
N4		87L-48	mineral separate	10	60.9-63.9	62.4	2.2	64.6	34.0	1.2	0.005	1.03	n.d.
N5		85L-25B	"	10	62.9-65.3	64.0	1.9	65.9	31.7	1.1	0.005	1.03	n.d.
N6		93L-2B		10	61.2-69.7	65.4	2.3	67.7	31.1	1.1	0.005	1.03	0.000
		Snowshoe Mtn. Tuff (intracaldera)											
S1		C8-71-4		6	70.3-72.8	71.5	2.3	73.8	25.3	0.9	0.004	1.01	n.d.
S2		C6-11-7		7	66.9-73.3	70.0	3.1	73.1	26.1	1.0	0.005	1.03	n.d.
		Snowshoe Mtn. Tuff (outflow)											
S3		C6-8-30A	sparse sanidine	3	69.2-73.1	71.2	2.5	73.7	25.4	1.0	0.005	1.03	0.000
S4		DAS87-140B	sparse sanidine	3	68.6-71.3	69.8	3.3	73.1	25.8	1.1	0.005	1.04	0.001
S5		87L-41	abundant sanidine	9	66.6-70.2	68.9	1.8	70.7	28.4	0.9	0.005	1.03	0.000
S6		69L-12		5	63.9-70.8	68.5	2.2	70.7	28.3	1.0	0.004	1.04	0.000
	depth	**Creede Drill Core Samples**											
D1	2123'	2R237-1.75A		6	70.3-71.8	71.2	2.5	73.7	25.2	1.1	0.004	1.03	0.001
D2	2168'	2R220A6.6B	abundant sanidine	8	70.1-72.5	71.4	2.6	74.0	24.9	1.0	0.005	1.02	n.d.
D3	2043'	2R207-2.4A	low potassium	2	59.8-63.4	62.0	5.9	64.0	34.0	2.0	0.005	1.05	0.005
"	"	"	high potassium	2	71.1-71.2	71.2	1.5	73.0	35.0	1.1	0.004	1.05	0.003
D4	2043'	clast-dacite		1		64.8	3.5	68.3	32.0	1.8	0.008	1.07	0.004
		Creede Channel Drill Core, Bulldog Mountain											
B1	435'	BM47C		5	60.7-66.5	63.0	3.3	66.2	32.6	1.2	0.005	1.04	0.004
B2	85'	BM36C		5	57.5-64.0	61.6	2.9	64.4	34.4	1.2	0.005	1.03	0.003
		MacDonough Reservoir											
M	(not shown)	85L-36		6	51.4-71.2	65.2	2.7	67.9	30.8	1.4	0.005	1.04	0.001

Sample types & locations for Table 2

Rat Creek Tuff

R Welded cliff-forming transitional rhyolite-dacite; paleomagnetic and Ar-Ar age site, southeast slope of Nelson Mountain

Nelson Mountain Tuff

Outflow sheet:

N1 Welded cliff-forming transitional rhyolite-dacite; paleomagnetic site, southeast slope of Nelson Mountain (coll. by J. Rosenbaum and R. Reynolds)

N2 Welded cliff-forming transitional rhyolite-dacite; Ar-Ar age site, southeast slope of Nelson Mountain

N3 Top of welded cliff-forming transitional dacite; paleomagnetic site at head of Miners Creek (coll. by J. Rosenbaum and R. Reynolds)

N4 Welded cliff-forming transitional rhyolite-dacite; Ar-Ar age site, west end of Snow Mesa above Spring Creek Pass

N5 Welded transitional rhyolite-dacite; paleomagnetic and Ar-Ar age site, Half Moon Pass

N6 Uppermost welded transitional rhyolite-dacite; immediately underlies separate ash-flow sheet, tentatively identified as Snowshoe Mtn Tuff (see S6)

Intracaldera:

I1 Upper welded dacite tuff unit, interleaved with postcaldera lava flows; along Continental Divide at head of East Willow Creek

I2 Uppermost partly welded dacite, immediately beneath postcaldera lava flows; along Sheep Creek, northeast of Bondholder Meadow

I3 Upper welded dacite, along north caldera wall; south of Mineral Mountain

I4 Densely welded devitrified dacite, from high in intracaldera tuff section; summit of San Luis Peak (coll. by D.A. Sawyer)

I5 Welded dacite middle levels of intracaldera tuff; along trail at saddle between East and West Spring Creeks

I6 Welded dacite, low in intracaldera tuff; west of Bondholder Meadow

I7 Welded transitional rhyolite-dacite; west of Bondholder Meadow

Snowshoe Mountain Tuff

Intracaldera:

S1 Partly welded gray tuff; paleomagnetic site near top of unit where overlain by conglomeratic Creede Formation south of McCall Creek (coll. by J. Rosenbaum and R. Reynolds)

S2 Partly welded gray tuff; paleomagnetic site near top of unit at Point of Rocks (coll. by J. Rosenbaum and R. Reynolds)

Outflow sheet:

S3 Partly welded gray tuff; paleomagnetic and Ar-Ar age site on Cattle Mountain, south of South Fork (coll. by J. Rosenbaum and R. Reynolds)

S4 Welded brown tuff; uppermost exposure, at paleomagnetic and Ar-Ar age site on north side of Palmer Mesa (correlation with Snowshoe Mtn Tuff is currently uncertain)

S5 Partly welded tan tuff; paleomagnetic site at head of Red Mountain Creek along Continental Divide

S6 Partly welded tan tuff; west of Stone Cellar, in north moat of La Garita caldera

Creede drill hole

D1 Partly welded gray tuff, bottom of drill hole 2, 2323 ft depth

D2 Partly welded gray tuff, near top of massive tuff, 2168 ft depth

D3 Lithic-rich tuff or tuffaceous debris flow, 2043 ft depth

D4 Lava clast, from lithic-rich tuff or tuffaceous debris flow, 2043 ft depth

Creede channel

B1 Gray dacitic welded tuff clast, in drill core, Bulldog Mtn area

B2 Gray dacitic welded tuff clast, in drill core, Bulldog Mtn area

McDonough Reservoir

M Partly welded dacitic tuff of uncertain stratigraphic affinity

Table 3. Microprobe analyses of two sanidine grains from sample I7

Microprobe analyses for grain A

wt% oxides	pt1 core	pt2	pt3	pt4 edge
SiO2	63.9	64.7	65.4	64.5
Al2O3	19.4	19.1	19.1	19.1
FeO*	0.15	0.13	0.14	0.10
MgO	0.00	0.00	0.00	0.00
BaO	2.02	1.51	0.91	1.27
SrO	0.13	0.09	0.12	0.15
CaO	0.28	0.21	0.20	0.25
Na2O	3.71	3.64	3.79	3.62
K2O	10.62	10.98	11.05	10.97
Total	100.2	100.4	100.7	100.0
cations				
Si	2.94	2.96	2.97	2.96
Al	1.05	1.03	1.02	1.03
Fe	0.006	0.005	0.005	0.004
Mg	0.000	0.000	0.000	0.000
Na	0.332	0.323	0.334	0.322
Ca	0.014	0.010	0.010	0.012
Ba	0.036	0.027	0.016	0.023
K	0.624	0.641	0.641	0.642
Sr	0.003	0.002	0.003	0.004
Total	5.01	5.00	5.00	5.00
	End member compositions			
Orthoclase	62.0	64.0	64.1	64.3
Albite	33.0	32.3	33.4	32.2
Anorthite	1.4	1.0	1.0	1.2
Celsian	3.6	2.7	1.6	2.3

Microprobe analyses for grain B

wt% oxides	pt1	pt2	pt3 bright rim
SiO2	65.0	65.4	63.3
Al2O3	19.4	19.3	20.1
FeO*	0.13	0.12	0.21
MgO	0.00	0.00	0.00
BaO	1.59	1.09	3.58
SrO	0.07	0.12	0.29
CaO	0.32	0.25	0.41
Na2O	4.30	4.07	3.99
K2O	10.30	10.60	9.71
Total	101.1	100.9	101.6
cations			
Si	2.95	2.97	2.90
Al	1.04	1.03	1.09
Fe	0.005	0.004	0.008
Mg	0.000	0.000	0.000
Na	0.379	0.358	0.355
Ca	0.016	0.012	0.020
Ba	0.028	0.019	0.064
K	0.597	0.613	0.568
Sr	0.002	0.003	0.008
Total	5.02	5.01	5.01
	End member compositions		
Orthoclase	58.6	61.2	56.4
Albite	37.2	35.7	35.2
Anorthite	1.5	1.2	2.0
Celsian	2.8	1.9	6.4

Table 4. Representative sanidine analyses

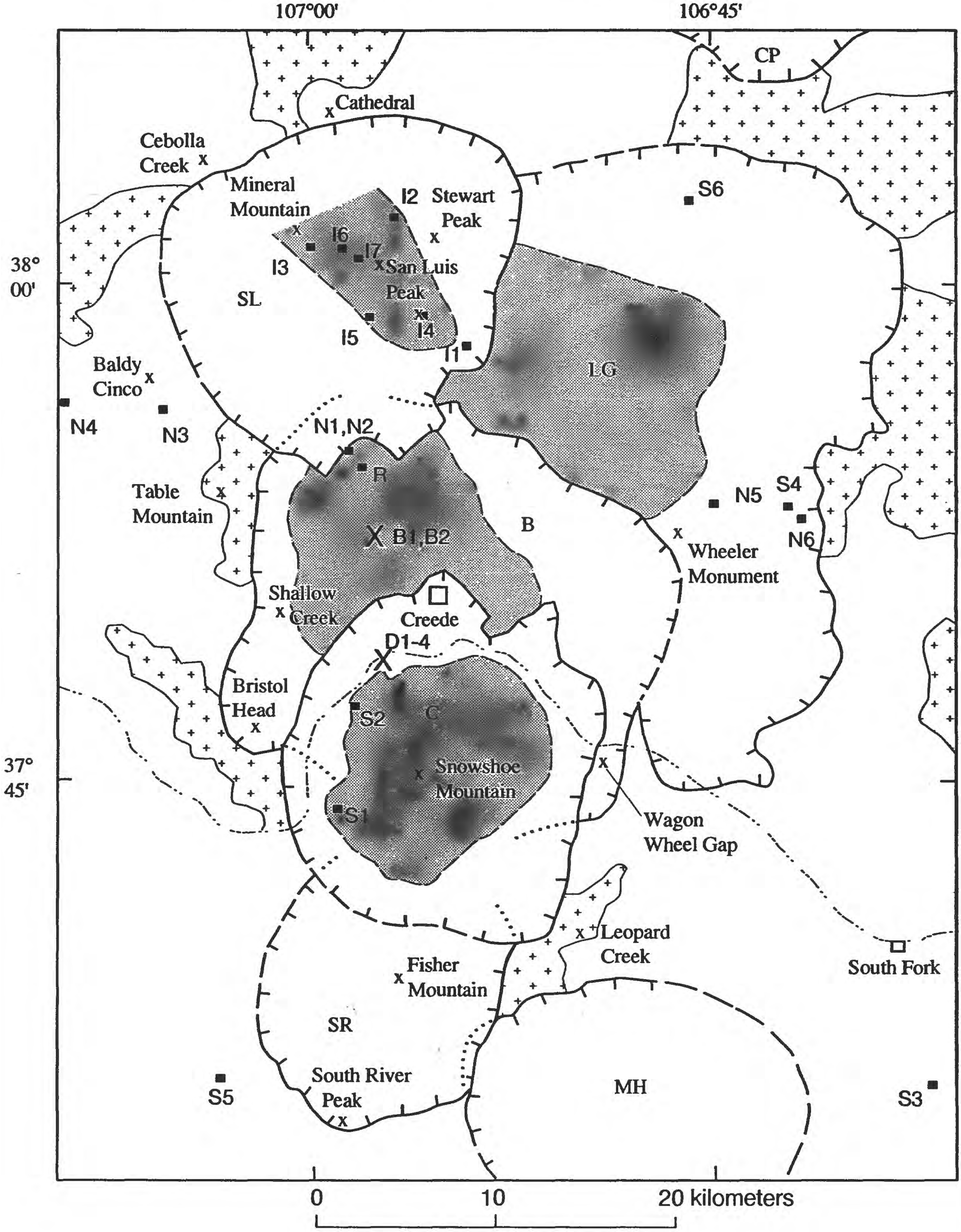
Map ref #	R	N2	I1	I3	I6	S2	S6
Analysis#(SS)	95	57	54	52	4	51	14
Wt% oxides							
SiO2	64.9	64.6	65.1	64.8	64.4	64.4	64.0
Al2O3	19.1	19.1	18.8	19.0	18.6	19.2	19.3
FeO*	0.11	0.15	0.13	0.11	0.15	0.14	0.13
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.24	0.23	0.24	0.22	0.17	0.22	0.19
BaO	1.23	1.51	0.89	0.92	0.41	2.10	1.29
SrO	0.00	0.11	0.10	0.17	0.07	0.00	0.00
Na2O	3.78	3.72	3.67	3.01	3.63	2.73	2.87
K2O	10.58	10.91	10.91	12.02	11.54	11.75	11.52
Total	99.9	100.4	99.8	100.3	99.0	100.5	99.3
cations: oxygen = 8							
Si	2.97	2.96	2.98	2.97	2.98	2.96	2.96
Al	1.03	1.03	1.01	1.03	1.01	1.04	1.05
Fe	0.004	0.006	0.005	0.004	0.006	0.005	0.004
Mg	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Na	0.335	0.330	0.326	0.267	0.325	0.243	0.257
Ca	0.012	0.011	0.012	0.011	0.008	0.011	0.010
Sr	0.000	0.003	0.003	0.005	0.002	0.000	0.000
K	0.618	0.637	0.637	0.702	0.680	0.689	0.679
Ba	0.022	0.027	0.016	0.017	0.008	0.038	0.023
Total	4.99	5.01	4.99	5.00	5.02	4.98	4.98
end member compositions							
Or	62.6	63.3	64.3	70.5	66.6	70.3	70.1
Ab	34.0	32.8	32.9	26.8	31.8	24.8	26.5
An	1.2	1.1	1.2	1.1	0.8	1.1	1.0
Cn	2.2	2.7	1.6	1.7	0.7	3.9	2.4

Map ref #	D1	D4	B2	M	M
Analysis#(SS)	11	25	58	48	52
SiO2	62.8	63.0	63.3	64.0	65.1
Al2O3	19.2	19.4	18.4	19.2	19.5
FeO*	0.10	0.17	0.14	0.10	0.21
MgO	0.00	0.01	0.00	0.00	0.00
CaO	0.22	0.36	0.21	0.24	0.31
BaO	1.88	2.07	1.54	1.40	1.75
SrO	0.17	0.15	0.15	0.00	0.05
Na2O	2.72	3.44	3.53	2.82	3.59
K2O	11.61	10.68	10.00	11.52	10.58
Total	98.7	99.2	97.2	99.3	101.1
Si	2.94	2.93	2.98	2.96	2.96
Al	1.06	1.06	1.02	1.05	1.04
Fe	0.004	0.007	0.005	0.003	0.007
Mg	0.000	0.000	0.000	0.000	0.000
Na	0.247	0.310	0.322	0.253	0.316
Ca	0.011	0.018	0.010	0.012	0.015
Sr	0.005	0.004	0.004	0.000	0.001
K	0.694	0.634	0.601	0.680	0.613
Ba	0.035	0.038	0.028	0.025	0.031
Total	5.00	5.01	4.97	4.98	4.98
Or	70.3	63.4	62.5	70.1	62.9
Ab	25.1	31.0	33.5	26.1	32.4
An	1.1	1.8	1.1	1.2	1.6
Cn	3.5	3.8	3.0	2.6	3.2

Table 5. Representative hornblende analyses

map ref #	N6	CC	S2	S3	M
wt% oxides					
SiO2	48.2	44.6	44.8	47.0	43.9
TiO2	1.13	2.19	1.67	1.50	2.13
Al2O3	6.15	9.25	8.80	7.46	9.88
FeO	12.8	12.1	14.7	13.2	13.8
MnO	0.97	0.69	0.66	0.65	0.64
MgO	15.1	14.1	13.0	14.1	12.7
CaO	11.6	11.3	11.6	11.6	12.0
Na2O	1.31	1.86	1.65	1.30	1.73
K2O	0.59	0.82	0.99	0.75	1.03
Cl	0.06	0.06	0.13	0.11	0.10
F	0.12	0.32	0.35	0.32	0.02
-O	-0.07	-0.15	-0.18	-0.16	-0.03
Total	98.1	97.1	98.1	97.8	97.8
cations: oxygen = 24					
Si	7.36	6.91	6.96	7.22	6.82
Al	1.11	1.69	1.61	1.35	1.81
Ti	0.130	0.255	0.195	0.173	0.248
Fe	1.64	1.57	1.91	1.69	1.79
Mg	3.44	3.25	3.01	3.22	2.93
Mn	0.126	0.091	0.087	0.085	0.084
Na	0.388	0.557	0.497	0.386	0.520
Ca	1.90	1.87	1.93	1.92	1.99
K	0.115	0.161	0.196	0.148	0.204
Cl	0.015	0.016	0.033	0.027	0.026
F	0.059	0.157	0.173	0.155	0.011
Total	16.28	16.52	16.59	16.38	16.43

Figure 1. Sample location map, central San Juan caldera cluster



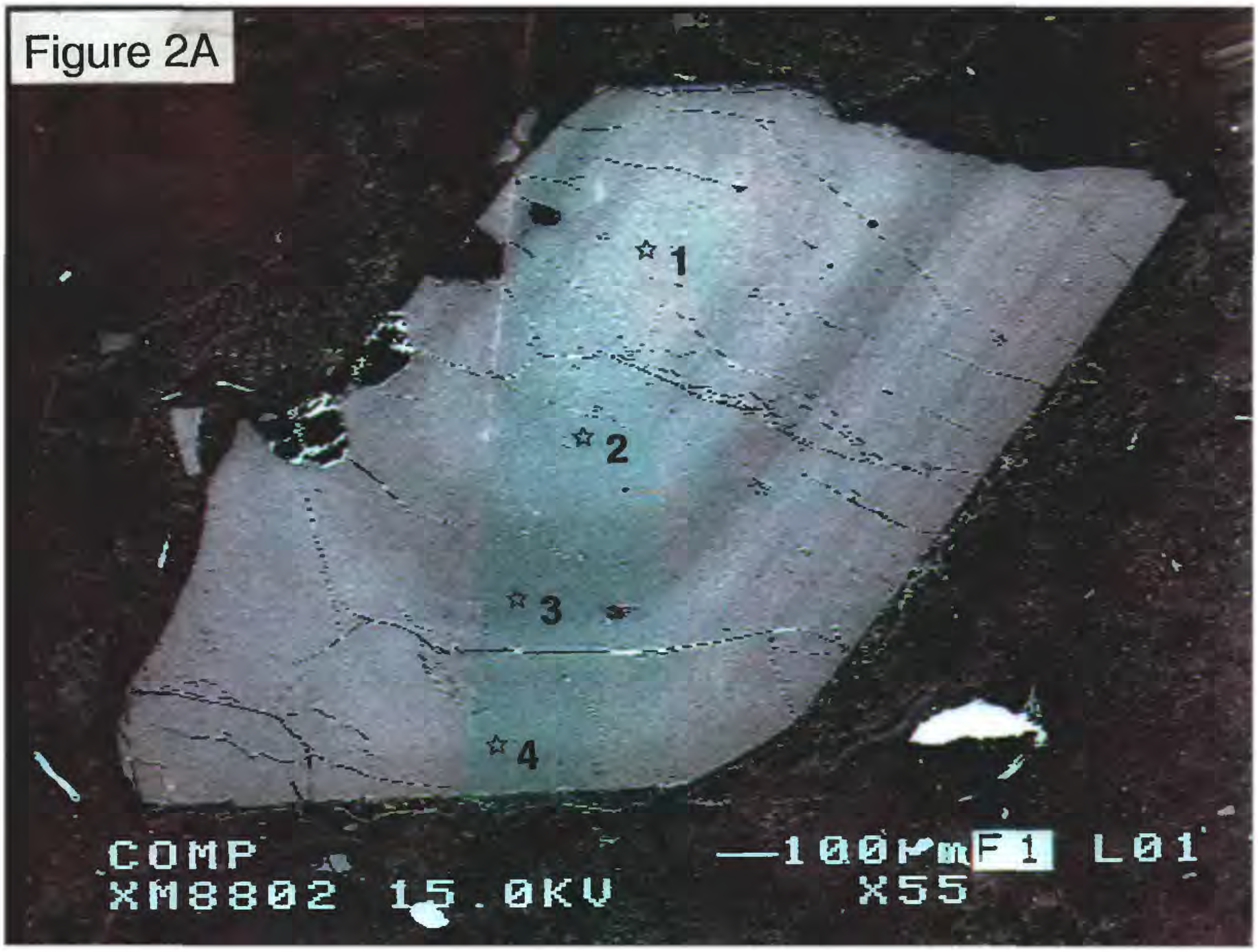


Figure 2A

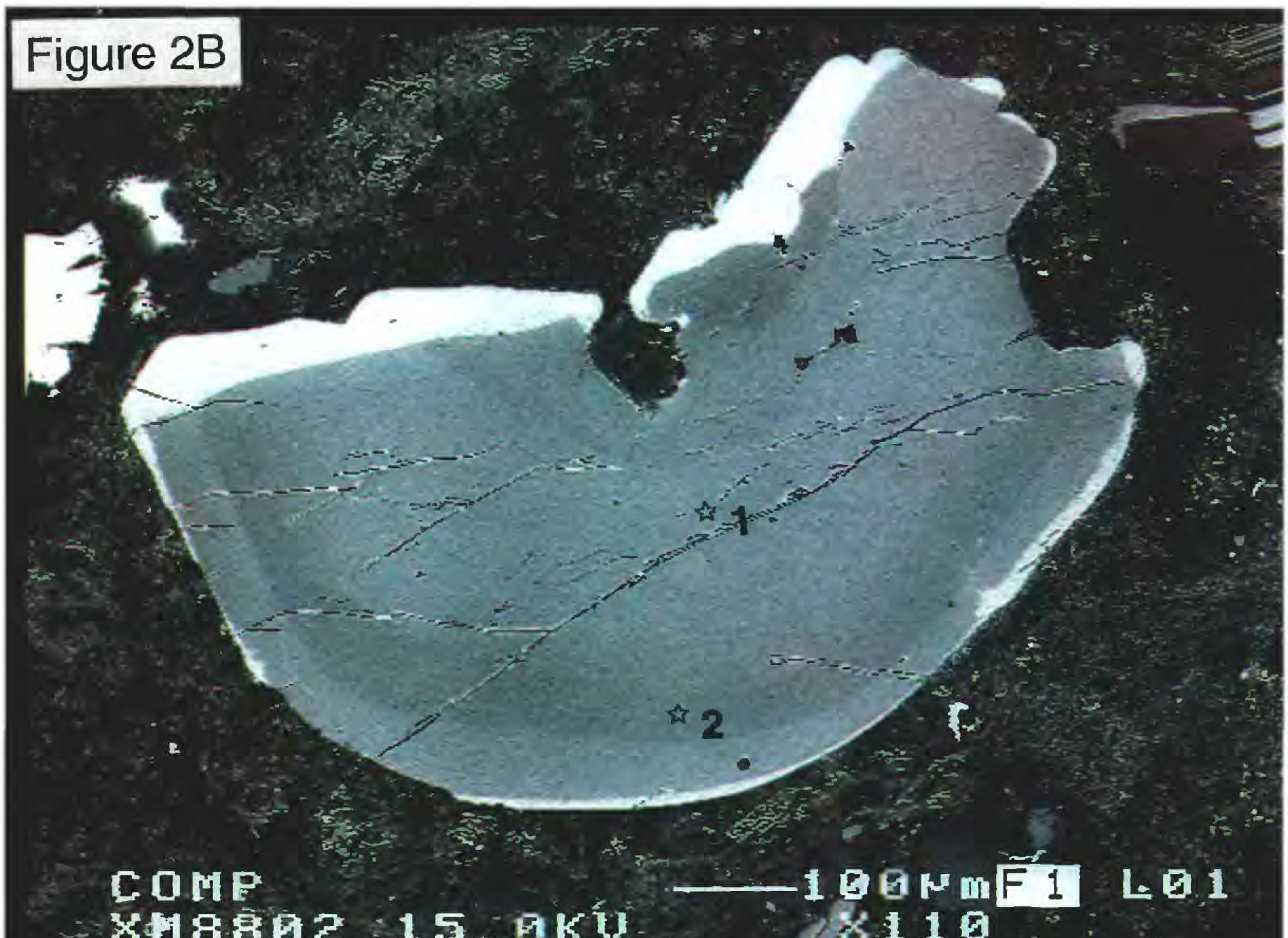


Figure 2B

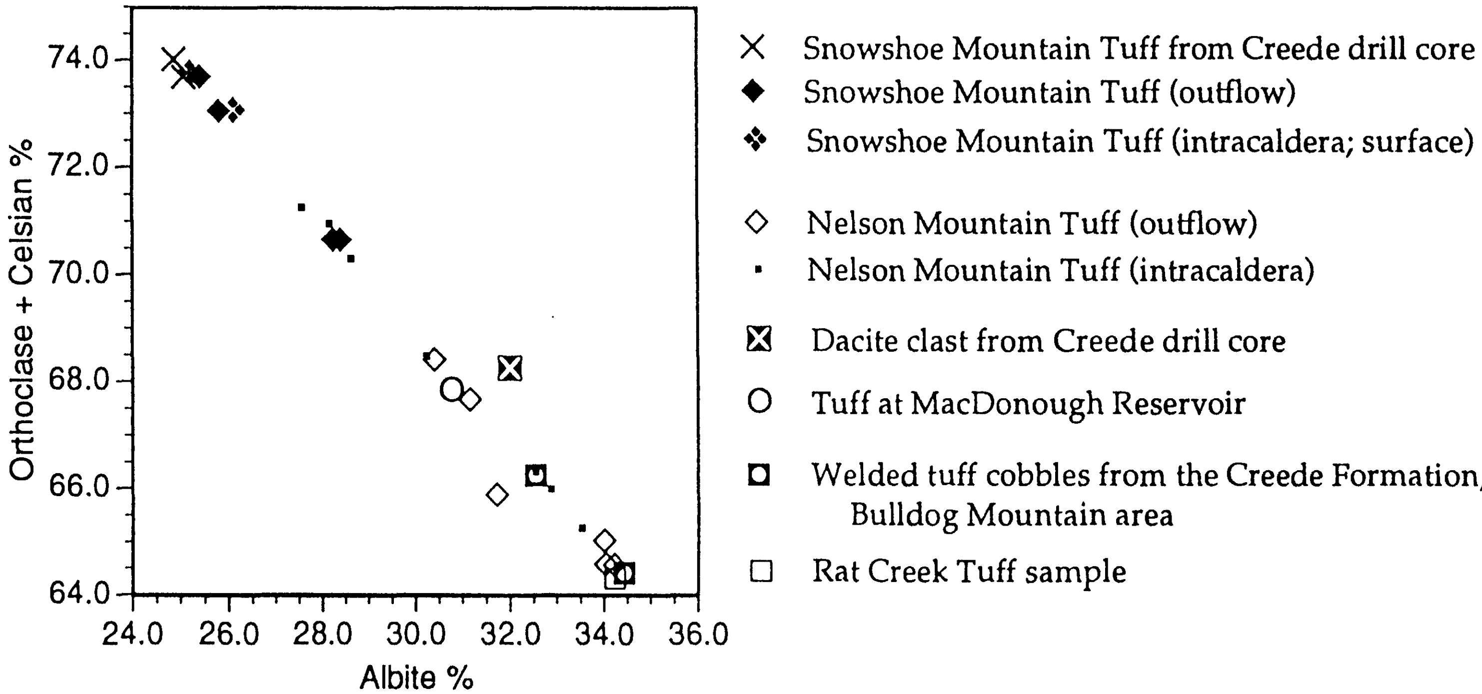


Figure 3. Sanidine analyses averaged by sample.

Figure 4A. Rat Creek and Nelson Mountain Tuffs

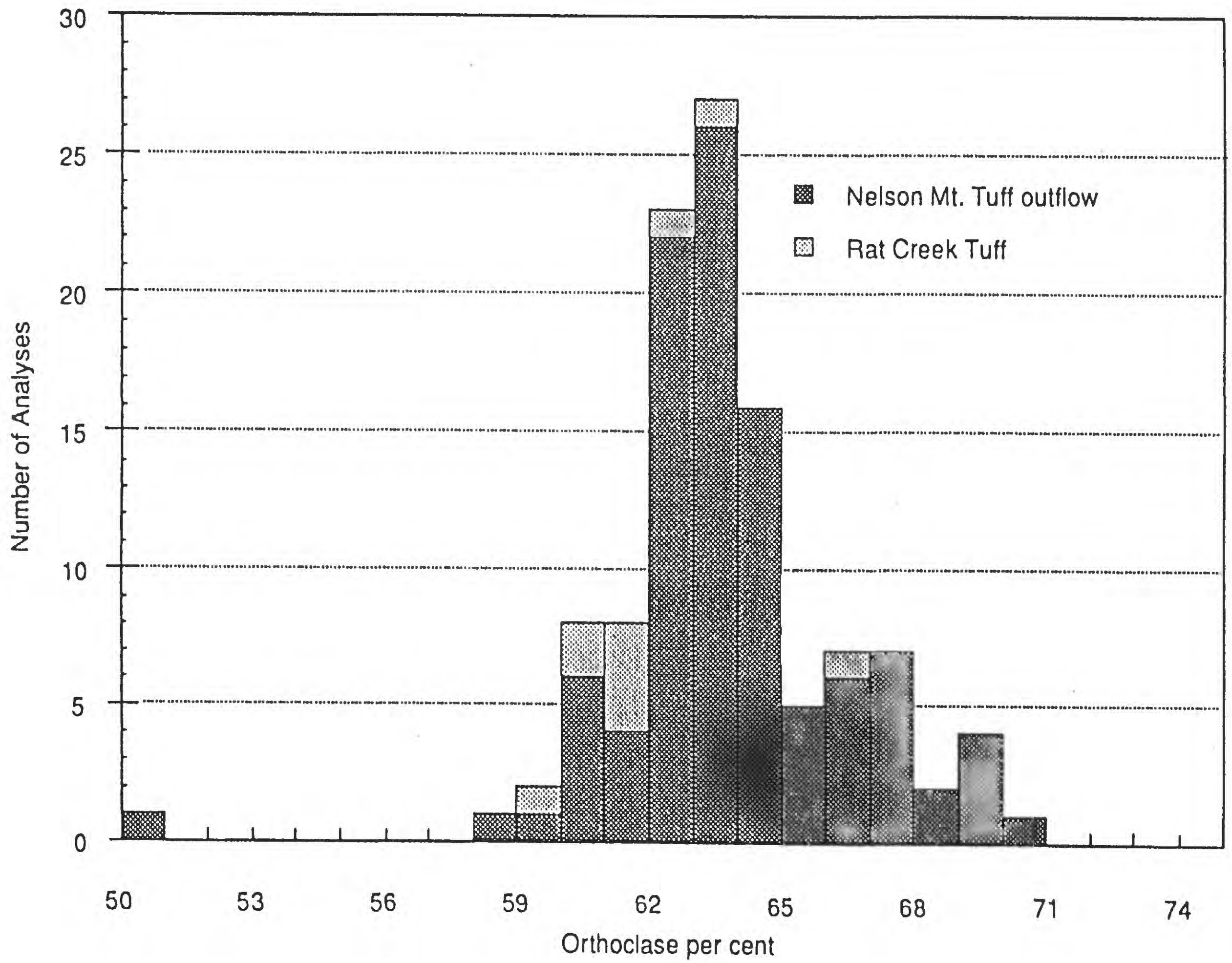


Figure 4B: Intracaldera Nelson Mountain Tuff

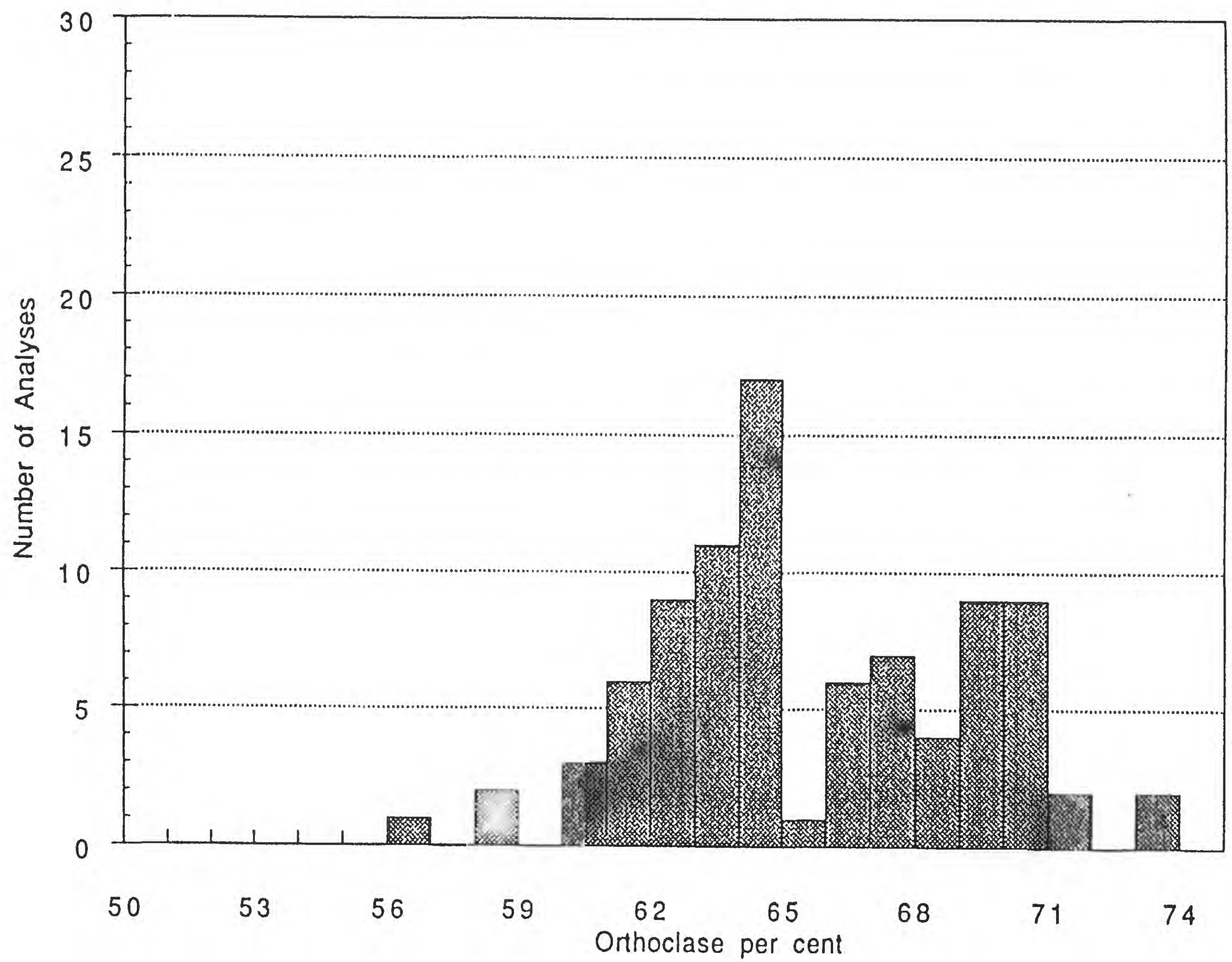
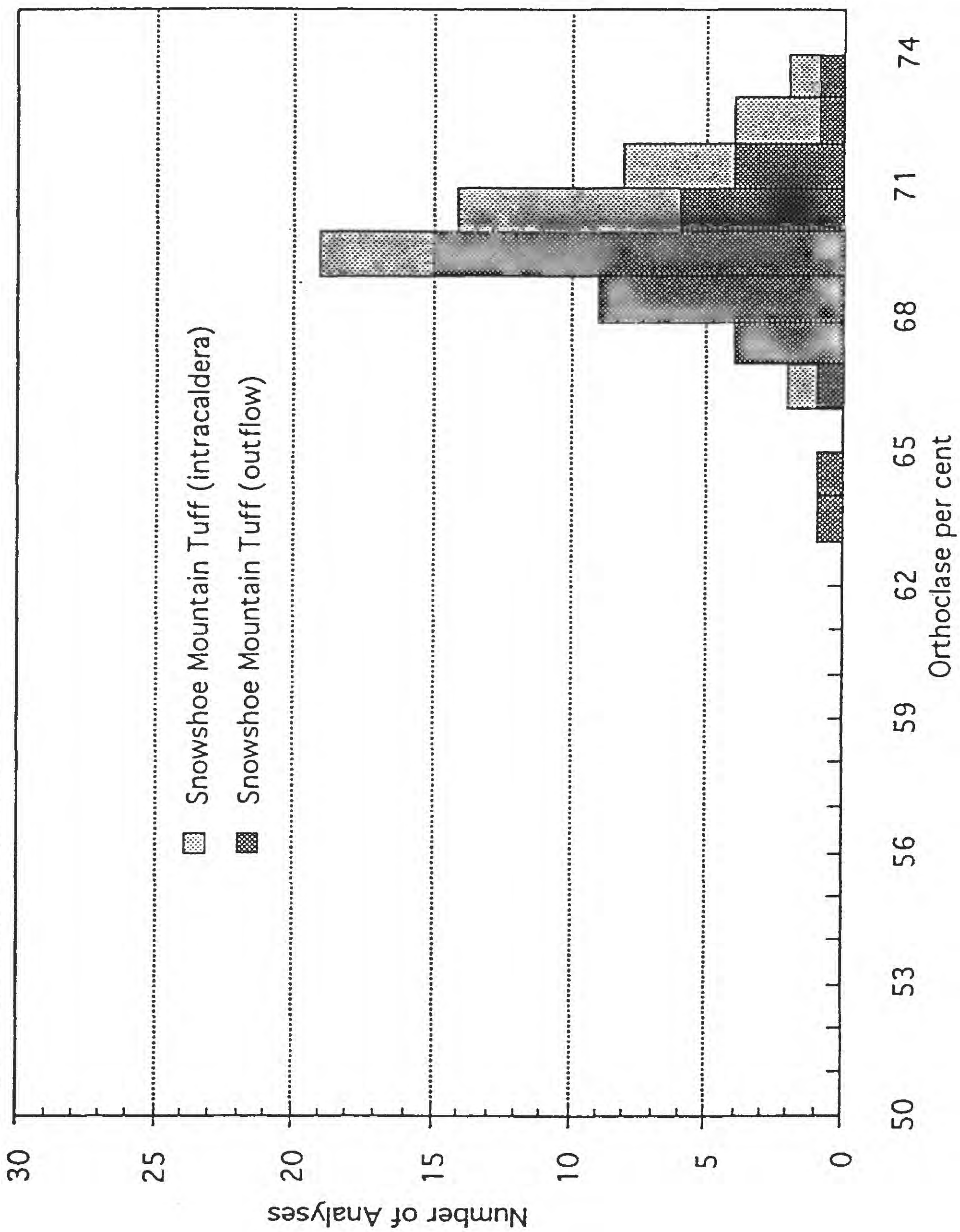


Figure 4C. Snowshoe Mountain Tuff



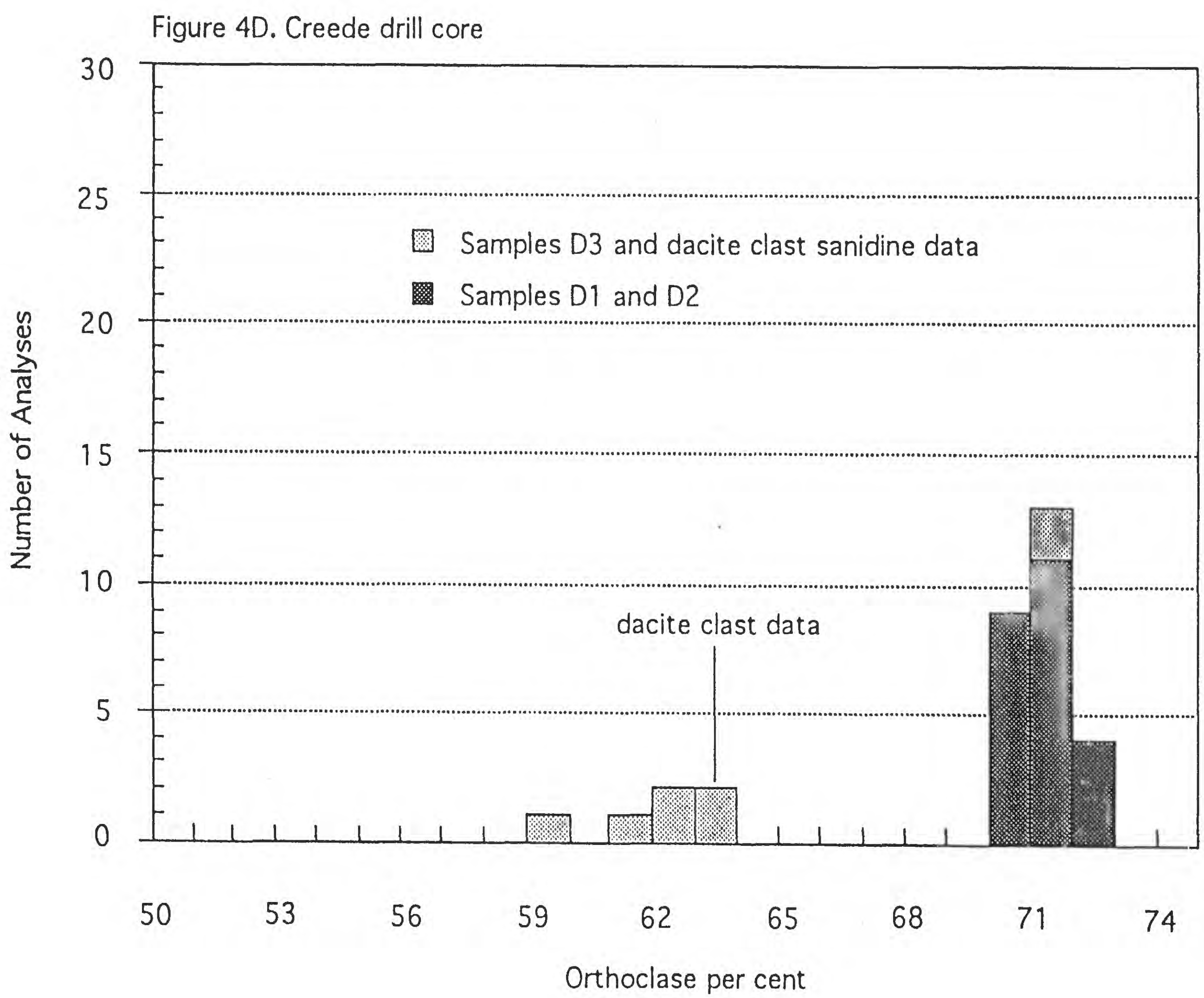


Figure 4D. Creede drill core
Samples D3 and dacite clast sanidine data
Samples D1 and D2
dacite clast data
Number of Analyses
0
5
10
15
20
25
30
50
53
56
59
62
65
68
71
74
Orthoclase per cent

Figure 4E: Welded tuff cobbles from Creede Fm., Bulldog Mine

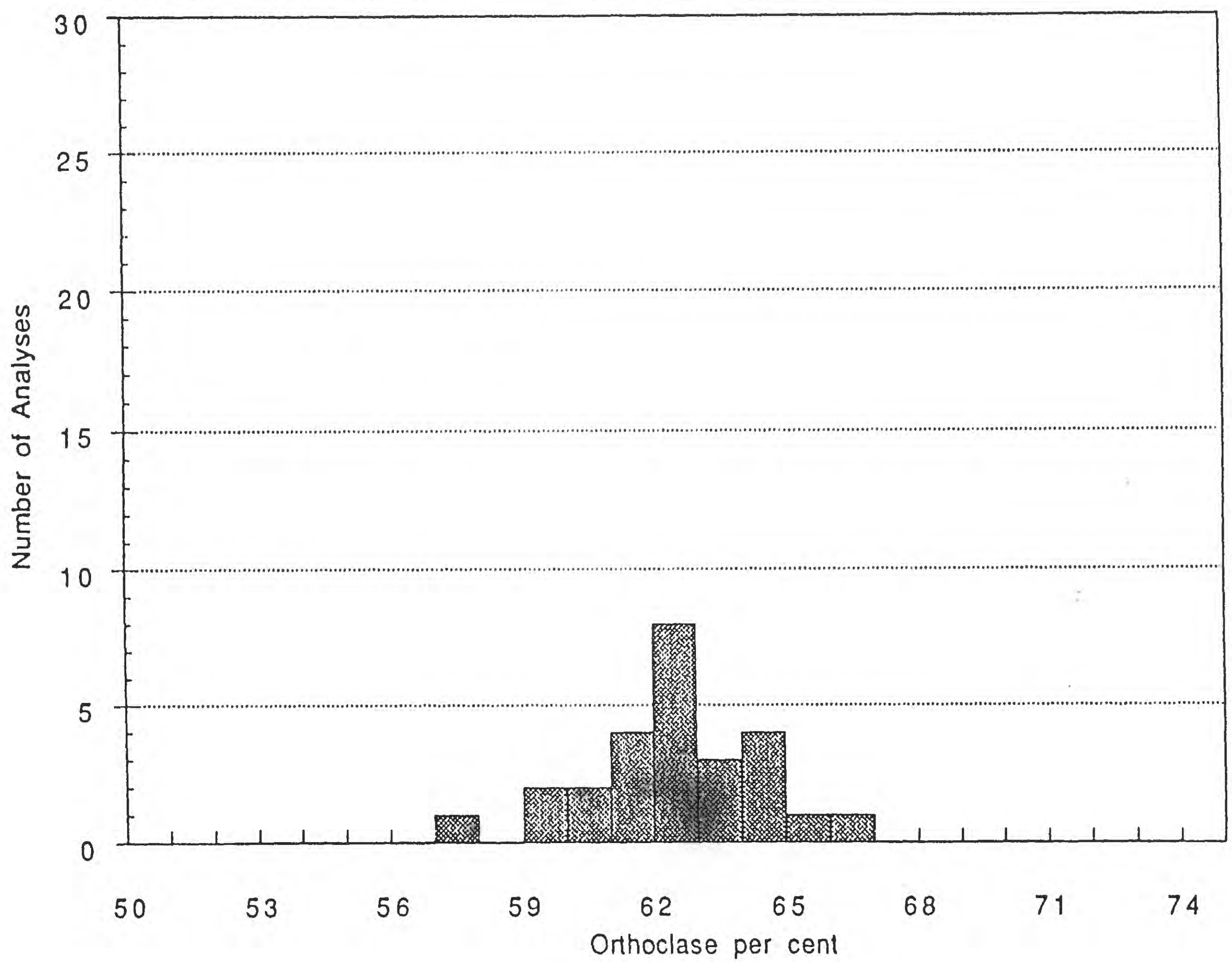


Figure 4F: Tuff at MacDonough Reservoir

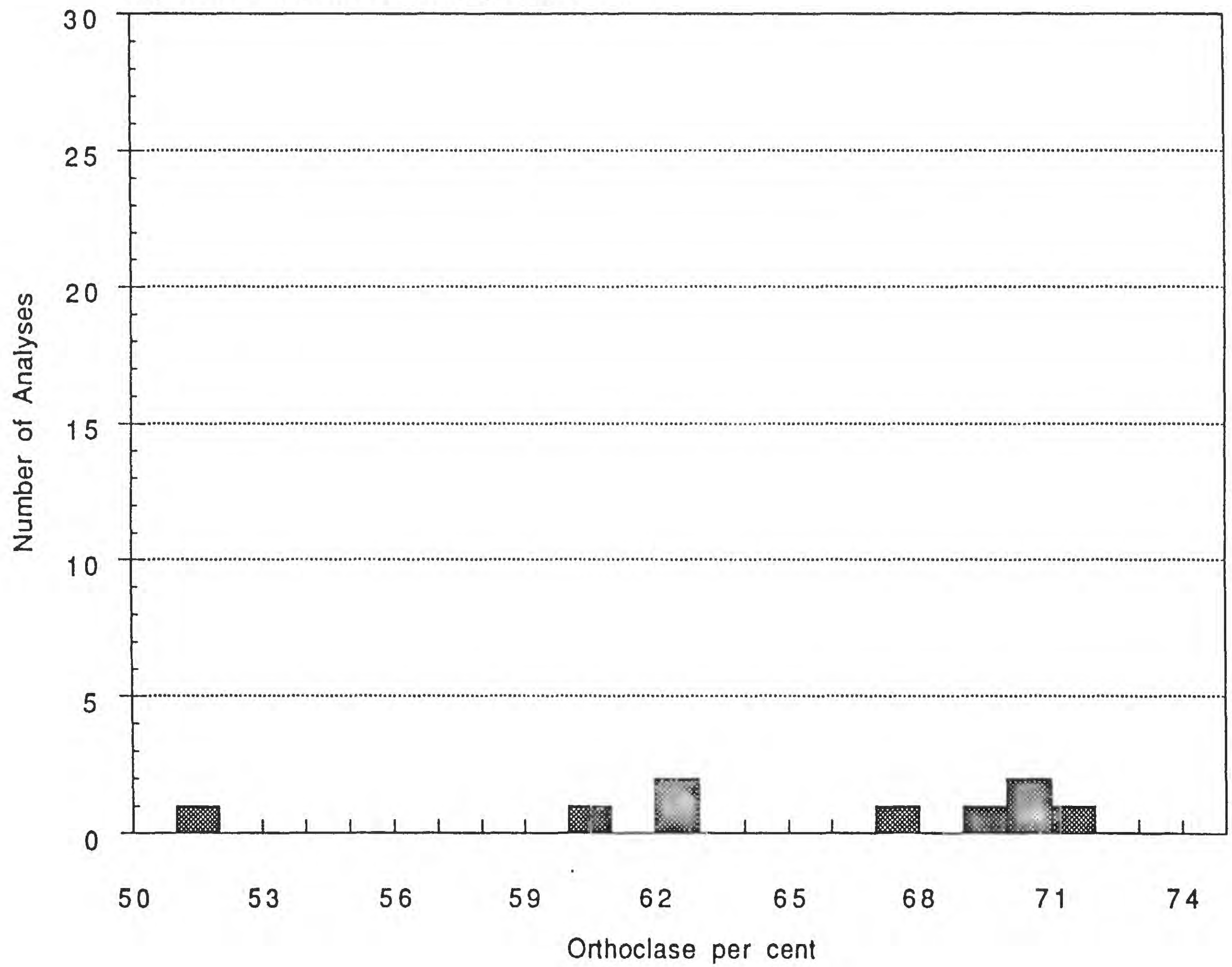
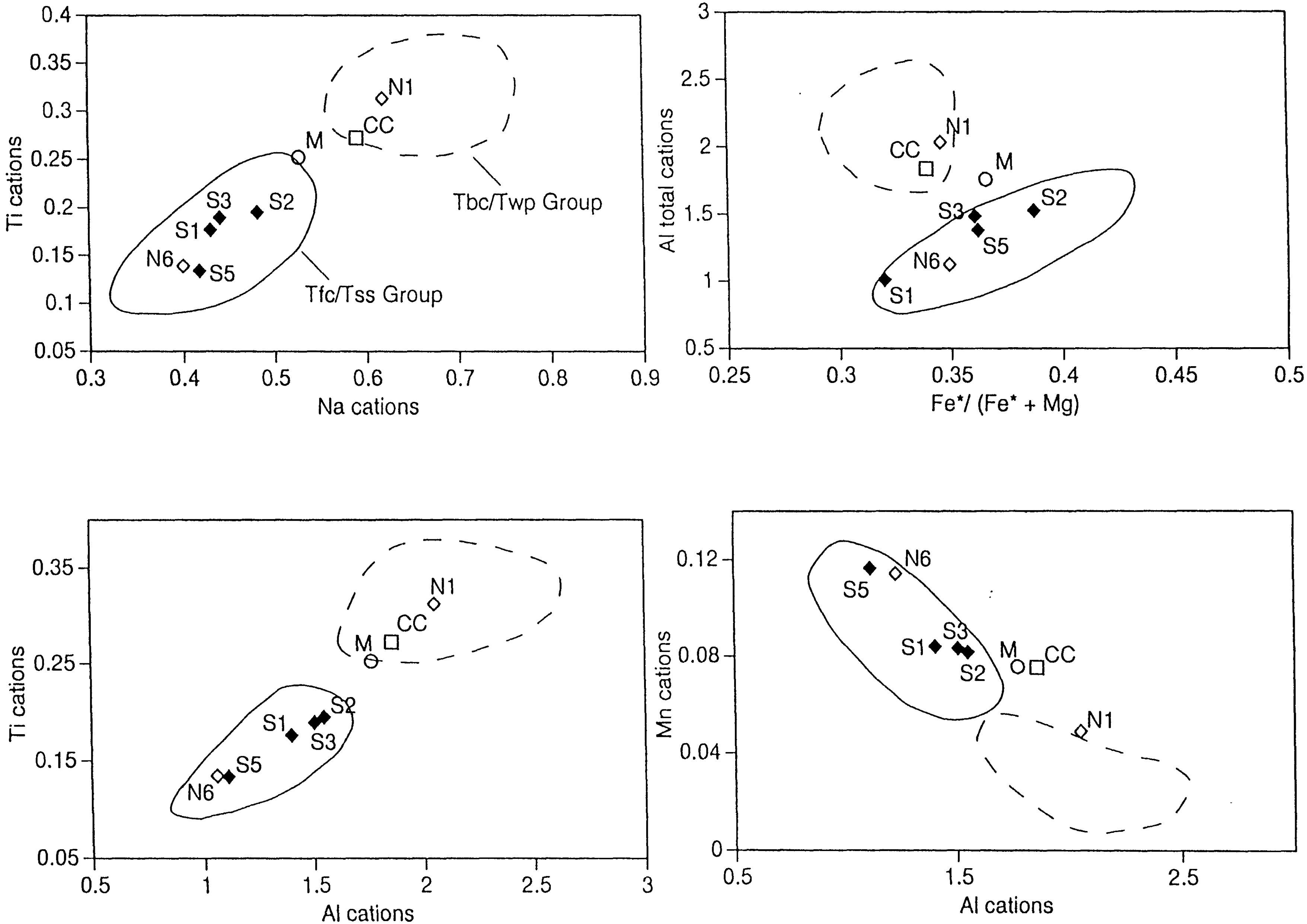


Figure 5. Average hornblende compositions



Appendix 1. Individual point analyses, # sanidine phenocrysts, cations and end member mol %

Abbreviations: c, core; e, edge; m, middle; sm, small; r, rim

Rat Creek Tuff					cations, oxygen = 8						End Member mol %			
Map ref.	Sample Name	Si	Al	Fe	Mg	Na	Ca	K	Ba	Sr	Total	Or	An	Ab	Cn
R	85L-29F-1	2.94	1.07	0.006	0.000	0.328	0.018	0.576	0.045	0.000	4.98	59.6	1.8	33.9	4.7
R	85L-29F-1	2.94	1.05	0.005	0.000	0.334	0.016	0.611	0.039	0.000	5.00	61.1	1.6	33.4	3.9
R	85L-29F-2	2.98	1.02	0.005	0.000	0.348	0.012	0.607	0.017	0.000	4.99	61.7	1.2	35.4	1.7
R	85L-29F-2	2.97	1.03	0.004	0.000	0.335	0.012	0.618	0.022	0.000	4.99	62.6	1.2	34.0	2.2
R	85L-29F-3	2.97	1.04	0.005	0.000	0.347	0.011	0.600	0.017	0.000	4.98	61.6	1.1	35.6	1.7
R	85L-29F-3	2.98	1.02	0.004	0.000	0.352	0.010	0.613	0.014	0.000	4.99	62.0	1.1	35.6	1.4
R	85L-29F-4	2.97	1.03	0.006	0.000	0.352	0.011	0.598	0.022	0.000	4.99	60.8	1.1	35.8	2.3
R	85L-29F-4	2.96	1.04	0.004	0.000	0.308	0.013	0.668	0.013	0.000	5.01	66.7	1.2	30.7	1.3
R	85L-29F-5.1	2.96	1.04	0.008	0.000	0.347	0.018	0.599	0.018	0.000	4.99	61.0	1.8	35.4	1.8
R	85L-29F-5.2	2.98	1.01	0.007	0.000	0.324	0.019	0.618	0.019	0.000	4.98	63.1	1.9	33.1	1.9
Average		**2.96**	**1.04**	**0.005**	**0.000**	**0.338**	**0.014**	**0.611**	**0.023**	**0.000**	**4.99**	**62.0**	**1.4**	**34.3**	**2.3**
Sigma		**0.01**	**0.02**	**0.001**	**0.000**	**0.015**	**0.003**	**0.024**	**0.011**	**0.000**	**0.01**	**1.9**	**0.3**	**1.6**	**1.1**
Nelson Mountain Tuff		**Si**	**Al**	**Fe**	**Mg**	**Na**	**Ca**	**K**	**Ba**	**Sr**	**Total**	**Or**	**An**	**Ab**	**Cn**
N1	C5-6-14 grotty san near biotite	2.99	1.02	0.006	0.000	0.317	0.011	0.629	0.009	0.000	4.98	65.1	1.2	32.8	0.9
N1	C5-6-14 grotty san near biotite	3.00	1.00	0.004	0.001	0.312	0.011	0.643	0.010	0.000	4.98	65.9	1.2	31.9	1.0
N1	C5-6-14	2.99	0.99	0.005	0.010	0.341	0.012	0.649	0.013	0.000	5.01	63.9	1.2	33.6	1.2
N1	C5-6-14	3.00	0.99	0.005	0.000	0.341	0.012	0.649	0.009	0.000	5.00	64.2	1.2	33.7	0.9
N1	C5-6-14	2.99	0.99	0.007	0.011	0.310	0.011	0.675	0.010	0.000	5.00	67.2	1.0	30.8	1.0
N1	C5-6-14	3.00	0.98	0.006	0.000	0.327	0.013	0.663	0.013	0.000	5.00	65.2	1.3	32.1	1.3
N1	C5-6-14	2.99	1.00	0.005	0.000	0.308	0.014	0.666	0.016	0.000	5.00	66.4	1.4	30.7	1.6
N1	C5-6-14	3.00	0.99	0.004	0.000	0.288	0.011	0.685	0.012	0.000	4.99	68.8	1.1	28.9	1.2
N1	C5-6-14	3.00	0.98	0.004	0.000	0.278	0.011	0.709	0.009	0.000	5.00	70.5	1.1	27.6	0.9
N1	C5-6-14	2.98	1.00	0.005	0.000	0.286	0.011	0.663	0.026	0.000	5.00	67.8	1.1	28.4	2.6
N1	C5-6-14	2.99	0.99	0.005	0.009	0.275	0.011	0.703	0.022	0.000	5.00	69.6	1.0	27.2	2.1
N1	C5-6-14	2.99	1.00	0.006	0.000	0.292	0.010	0.673	0.020	0.000	4.99	67.6	1.0	29.4	2.0
N1	C5-6-14	2.97	1.01	0.006	0.000	0.313	0.011	0.678	0.020	0.000	5.01	66.4	1.1	30.6	1.9
N1	C5-6-14	2.98	1.00	0.004	0.018	0.290	0.014	0.666	0.023	0.000	4.99	67.1	1.4	29.2	2.3
N1	C5-6-14	3.01	0.98	0.004	0.000	0.317	0.010	0.665	0.013	0.000	4.99	66.1	0.9	31.8	1.3
N1	C5-6-14	2.99	1.00	0.003	0.000	0.320	0.011	0.656	0.015	0.000	4.99	65.5	1.1	32.0	1.5
N1	C5-6-14	2.99	0.99	0.004	0.001	0.316	0.013	0.671	0.014	0.000	5.00	66.2	1.2	31.1	1.4
N2	85L-29C	2.97	1.04	0.005	0.000	0.325	0.011	0.635	0.016	0.002	5.00	64.3	1.1	32.9	1.7
N2	85L-29C	2.97	1.02	0.005	0.000	0.335	0.011	0.647	0.018	0.003	5.01	64.0	1.1	33.1	1.8
N2	85L-29C	2.97	1.03	0.005	0.000	0.327	0.011	0.636	0.019	0.003	5.00	64.1	1.1	32.9	1.9
N2	85L-29C	2.98	1.03	0.005	0.000	0.329	0.010	0.640	0.021	0.004	5.00	64.0	1.0	32.9	2.1
N2	85L-29C	2.98	1.02	0.005	0.000	0.316	0.011	0.643	0.014	0.001	4.99	65.3	1.1	32.1	1.5
N2	85L-29C	2.95	1.04	0.007	0.000	0.340	0.013	0.624	0.029	0.001	5.01	62.0	1.3	33.8	2.9
N2	85L-29C	2.95	1.05	0.006	0.000	0.356	0.014	0.612	0.030	0.004	5.01	60.5	1.4	35.2	3.0

Map ref.	Sample Name	Si	Al	Fe	Mg	Na	Ca	K	Ba	Sr	Total	Or	An	Ab	Cn
N2	85L-29C	2.92	1.07	0.006	0.000	0.342	0.017	0.613	0.043	0.005	5.02	60.4	1.7	33.7	4.2
N2	85L-29C	2.93	1.07	0.005	0.000	0.343	0.016	0.613	0.044	0.004	5.02	60.4	1.6	33.8	4.3
N2	85L-29C	2.97	1.03	0.006	0.000	0.377	0.014	0.588	0.019	0.003	5.00	58.9	1.4	37.8	1.9
N2	85L-29C	2.97	1.03	0.006	0.000	0.461	0.014	0.504	0.019	0.004	5.00	50.5	1.4	46.2	1.9
N2	85L-29C	2.97	1.02	0.004	0.000	0.330	0.011	0.641	0.016	0.001	5.00	64.2	1.1	33.0	1.6
N2	85L-29C	2.98	1.02	0.004	0.000	0.346	0.010	0.626	0.015	0.001	5.00	62.8	1.0	34.7	1.5
N2	85L-29C	2.97	1.02	0.004	0.000	0.336	0.012	0.629	0.017	0.002	5.00	63.3	1.2	33.8	1.8
N2	85L-29C	2.97	1.03	0.005	0.000	0.337	0.012	0.637	0.020	0.003	5.01	63.3	1.2	33.4	2.0
N2	85L-29C	2.96	1.03	0.005	0.000	0.325	0.012	0.651	0.019	0.004	5.01	64.7	1.1	32.3	1.8
N2	85L-29C	2.97	1.01	0.005	0.000	0.329	0.012	0.649	0.021	0.003	5.01	64.2	1.2	32.5	2.1
N2	85L-29C	2.96	1.03	0.006	0.000	0.330	0.011	0.637	0.027	0.003	5.01	63.3	1.1	32.8	2.7
N2	85L-29C	2.98	1.02	0.004	0.000	0.325	0.012	0.631	0.025	0.003	4.99	63.6	1.2	32.7	2.5
N3	C5-18-3 lone center	2.96	1.05	0.003	0.000	0.324	0.011	0.607	0.030	0.000	4.98	62.4	1.2	33.3	3.1
N3	C5-18-3 lone edge	2.96	1.04	0.005	0.000	0.327	0.012	0.607	0.032	0.000	4.98	62.0	1.2	33.5	3.3
N3	C5-18-3 group of sanidines	2.96	1.04	0.006	0.001	0.325	0.011	0.612	0.025	0.000	4.98	62.9	1.2	33.4	2.6
N3	C5-18-3 group of sanidines	2.98	1.02	0.006	0.000	0.338	0.011	0.617	0.017	0.000	4.99	62.8	1.1	34.4	1.7
N3	C5-18-3 group of sanidines	2.96	1.04	0.006	0.000	0.325	0.012	0.617	0.028	0.000	4.99	62.9	1.2	33.1	2.8
N3	C5-18-3 group of sanidines	2.95	1.05	0.006	0.000	0.346	0.016	0.595	0.039	0.000	5.00	59.8	1.6	34.8	3.9
N3	C5-18-3 group of sanidines	2.97	1.03	0.005	0.000	0.327	0.009	0.613	0.019	0.000	4.98	63.3	1.0	33.7	2.0
N3	C5-18-3 group of sanidines	2.97	1.03	0.006	0.000	0.341	0.010	0.608	0.023	0.000	4.99	61.9	1.1	34.7	2.4
N3	C5-18-3 group of sanidines	2.95	1.05	0.005	0.000	0.337	0.011	0.629	0.026	0.000	5.01	62.7	1.1	33.6	2.6
N3	C5-18-3 group of sanidines	2.96	1.04	0.004	0.001	0.324	0.010	0.632	0.024	0.000	4.99	63.8	1.0	32.8	2.4
N3	C5-18-3 group of sanidines	2.97	1.03	0.006	0.000	0.317	0.012	0.616	0.023	0.000	4.98	63.6	1.3	32.7	2.4
N3	C5-18-3 group of sanidines	2.97	1.02	0.005	0.000	0.341	0.013	0.624	0.025	0.000	5.00	62.3	1.3	34.0	2.5
N4	87L-48	2.97	1.02	0.005	0.000	0.360	0.011	0.608	0.021	0.002	5.00	60.9	1.1	36.0	2.1
N4	87L-48	2.97	1.02	0.006	0.000	0.356	0.012	0.615	0.023	0.003	5.01	61.1	1.2	35.4	2.3
N4	87L-48	2.97	1.03	0.005	0.000	0.337	0.012	0.614	0.026	0.002	4.99	62.1	1.2	34.1	2.6
N4	87L-48	2.96	1.04	0.007	0.000	0.346	0.012	0.627	0.022	0.003	5.01	62.3	1.2	34.4	2.2
N4	87L-48	2.98	1.02	0.005	0.000	0.347	0.008	0.631	0.013	0.002	5.00	63.1	0.8	34.7	1.3
N4	87L-48	2.98	1.02	0.005	0.000	0.338	0.012	0.618	0.016	0.003	4.99	62.8	1.2	34.4	1.6
N4	87L-48	2.96	1.03	0.005	0.000	0.332	0.012	0.632	0.024	0.003	5.00	63.3	1.2	33.2	2.4
N4	87L-48	2.96	1.03	0.004	0.000	0.331	0.011	0.634	0.026	0.003	5.00	63.3	1.1	33.0	2.6
N4	87L-48	2.95	1.04	0.005	0.000	0.335	0.012	0.629	0.032	0.004	5.01	62.4	1.2	33.2	3.2
N4	87L-48	2.96	1.03	0.006	0.000	0.349	0.012	0.603	0.025	0.002	4.99	61.0	1.2	35.3	2.5
N4	87L-48	2.97	1.03	0.005	0.000	0.335	0.012	0.626	0.018	0.003	5.00	63.2	1.2	33.8	1.8
N4	87L-48	2.98	1.01	0.005	0.000	0.339	0.012	0.624	0.021	0.004	5.00	62.6	1.2	34.0	2.1
N4	87L-48	2.95	1.04	0.005	0.000	0.330	0.012	0.634	0.028	0.004	5.01	63.1	1.2	32.9	2.8
N4	87L-48	2.96	1.04	0.006	0.000	0.330	0.013	0.623	0.030	0.003	5.00	62.5	1.3	33.1	3.0
N4	87L-48	2.97	1.02	0.006	0.000	0.336	0.011	0.631	0.020	0.003	5.00	63.2	1.1	33.7	2.0
N4	87L-48	2.95	1.04	0.005	0.000	0.346	0.012	0.622	0.028	0.003	5.01	61.7	1.2	34.3	2.8
N4	87L-48	2.97	1.03	0.003	0.000	0.335	0.013	0.617	0.021	0.004	4.99	62.6	1.4	34.0	2.1
N4	87L-48	2.97	1.02	0.004	0.000	0.333	0.013	0.624	0.020	0.004	4.99	63.1	1.3	33.7	2.0
N4	87L-48	2.97	1.02	0.004	0.000	0.342	0.011	0.639	0.017	0.002	5.01	63.4	1.0	33.9	1.7

Map ref.	Sample Name	Si	Al	Fe	Mg	Na	Ca	K	Ba	Sr	Total	Or	An	Ab	Cn
N4	87L-48	2.97	1.02	0.004	0.000	0.333	0.010	0.639	0.017	0.002	5.00	63.9	1.0	33.4	1.7
N5	85L-25B	2.96	1.03	0.006	0.000	0.319	0.012	0.637	0.025	0.004	5.00	64.2	1.2	32.1	2.5
N5	85L-25B	2.96	1.04	0.005	0.000	0.337	0.013	0.631	0.026	0.005	5.01	62.6	1.3	33.5	2.6
N5	85L-25B	2.97	1.02	0.005	0.000	0.326	0.012	0.640	0.018	0.002	5.00	64.3	1.2	32.8	1.8
N5	85L-25B	2.97	1.02	0.004	0.000	0.334	0.012	0.645	0.017	0.004	5.01	64.0	1.2	33.1	1.7
N5	85L-25B	2.97	1.02	0.004	0.000	0.345	0.010	0.629	0.016	0.002	5.00	62.9	1.0	34.5	1.6
N5	85L-25B	2.98	1.01	0.006	0.000	0.338	0.010	0.637	0.016	0.003	5.00	63.7	1.0	33.8	1.6
N5	85L-25B	2.97	1.03	0.005	0.000	0.322	0.013	0.629	0.027	0.002	4.99	63.5	1.3	32.4	2.7
N5	85L-25B	2.97	1.03	0.005	0.002	0.322	0.012	0.639	0.021	0.002	5.00	64.3	1.2	32.4	2.1
N5	85L-25B	2.96	1.04	0.005	0.000	0.329	0.013	0.632	0.025	0.004	5.00	63.3	1.3	32.9	2.5
N5	85L-25B	2.97	1.03	0.005	0.000	0.328	0.010	0.647	0.022	0.001	5.01	64.2	1.0	32.5	2.2
N5	85L-25B	2.97	1.02	0.005	0.000	0.321	0.011	0.649	0.022	0.003	5.00	64.7	1.1	32.0	2.2
N5	85L-25B	2.98	1.01	0.005	0.000	0.327	0.012	0.654	0.008	0.003	5.00	65.3	1.2	32.7	0.8
N5	85L-25B	2.98	1.02	0.004	0.000	0.332	0.012	0.652	0.009	0.003	5.01	64.9	1.2	33.0	0.8
N5	85L-25B	2.99	1.01	0.005	0.000	0.326	0.007	0.652	0.011	0.002	5.00	65.5	0.7	32.7	1.1
N5	85L-25B	2.96	1.03	0.004	0.001	0.333	0.011	0.640	0.021	0.003	5.01	63.7	1.1	33.1	2.0
N5	85L-25B	2.97	1.03	0.005	0.001	0.332	0.011	0.642	0.019	0.003	5.01	63.9	1.1	33.1	1.9
N5	85L-25B	2.96	1.03	0.004	0.000	0.330	0.012	0.641	0.023	0.004	5.01	63.7	1.2	32.8	2.3
N5	85L-25B	2.95	1.04	0.004	0.000	0.332	0.013	0.639	0.022	0.001	5.01	63.5	1.3	33.0	2.2
N6	93L-2Bs 1.1	2.96	1.05	0.005	0.000	0.289	0.011	0.673	0.019	0.000	5.00	67.8	1.1	29.1	1.9
N6	93L-2Bs 1.3	2.99	1.02	0.004	0.000	0.338	0.009	0.585	0.010	0.000	4.96	62.1	1.0	35.9	1.0
N6	93L-2Bs 2.1	2.96	1.04	0.005	0.000	0.336	0.012	0.624	0.022	0.000	5.00	62.8	1.2	33.8	2.2
N6	93L-2Bs 2.3	2.97	1.03	0.005	0.000	0.329	0.012	0.624	0.017	0.000	4.99	63.6	1.2	33.5	1.8
N6	93L-2Bs 3.1	2.96	1.04	0.004	0.000	0.271	0.010	0.684	0.016	0.000	4.99	69.7	1.0	27.6	1.7
N6	93L-2Bs 3.2	2.95	1.05	0.005	0.001	0.346	0.014	0.592	0.022	0.000	4.99	60.8	1.4	35.6	2.2
N6	93L-2Bs 4.1	2.96	1.05	0.004	0.000	0.264	0.010	0.654	0.035	0.000	4.97	67.9	1.0	27.4	3.6
N6	93L-2Bs 4.2	2.97	1.04	0.004	0.000	0.291	0.008	0.669	0.013	0.000	4.99	68.2	0.8	29.7	1.3
N6	93L-2Bs 5.1	2.93	1.07	0.005	0.000	0.327	0.014	0.629	0.037	0.001	5.01	62.5	1.4	32.5	3.6
N6	93L-2Bs 5.2	2.96	1.04	0.005	0.000	0.324	0.011	0.629	0.022	0.000	4.99	63.8	1.2	32.8	2.3
N6	93L-2B 1.1	2.95	1.06	0.006	0.000	0.262	0.011	0.674	0.024	0.000	4.99	69.4	1.2	26.9	2.5
N6	93L-2B 1.2	2.96	1.05	0.004	0.000	0.289	0.010	0.649	0.024	0.000	4.99	66.7	1.1	29.7	2.5
N6	93L-2B 2.1	2.96	1.05	0.004	0.000	0.271	0.009	0.640	0.038	0.000	4.97	66.8	0.9	28.3	4.0
N6	93L-2B 3.1	2.94	1.06	0.007	0.000	0.330	0.014	0.603	0.039	0.000	4.99	61.2	1.5	33.4	4.0
N6	93L-2B 4.1	3.00	1.00	0.006	0.000	0.278	0.007	0.671	0.015	0.000	4.97	69.1	0.7	28.6	1.6
N6	93L-2B 4.2	2.98	1.02	0.004	0.001	0.320	0.009	0.628	0.013	0.000	4.98	64.7	0.9	33.0	1.4
N6	93L-2B 5.1	2.97	1.04	0.004	0.000	0.284	0.009	0.643	0.024	0.000	4.97	67.0	0.9	29.6	2.5
N6	93L-2B 5.2	2.97	1.03	0.005	0.000	0.330	0.008	0.598	0.024	0.000	4.97	62.3	0.9	34.4	2.5
Average		**2.97**	**1.03**	**0.005**	**0.001**	**0.326**	**0.011**	**0.635**	**0.021**	**0.002**	**5.00**	**63.9**	**1.2**	**32.8**	**2.1**
Sigma		**0.02**	**0.02**	**0.001**	**0.002**	**0.025**	**0.002**	**0.027**	**0.007**	**0.002**	**0.01**	**2.6**	**0.2**	**2.4**	**0.7**

Nelson Mtn Tuff (intracaldera)		Si	Al	Fe	Mg	Na	Ca	K	Ba	Sr	Total	Or	An	Ab	Cn
I1	85L-11 1.1 c	2.97	1.02	0.004	0.000	0.324	0.010	0.638	0.021	0.003	5.00	64.3	1.0	32.6	2.1
I1	85L-11 1.2 e	2.98	1.02	0.004	0.000	0.335	0.012	0.625	0.017	0.003	4.99	63.2	1.3	33.8	1.7

Map ref.	Sample Name	Si	Al	Fe	Mg	Na	Ca	K	Ba	Sr	Total	Or	An	Ab	Cn
I1	85L-11 2.1 sm	2.97	1.03	0.005	0.000	0.335	0.013	0.625	0.023	0.004	5.00	62.8	1.3	33.6	2.3
I1	85L-11 3.1 c	2.98	1.02	0.005	0.000	0.327	0.010	0.631	0.018	0.002	4.99	64.0	1.0	33.2	1.8
I1	85L-11 3.2 e	2.97	1.02	0.004	0.000	0.325	0.011	0.621	0.027	0.005	4.99	63.2	1.1	33.0	2.7
I1	85L-11 4.1 c	2.98	1.02	0.005	0.000	0.327	0.011	0.622	0.022	0.003	4.99	63.4	1.1	33.3	2.2
I1	85L-11 4.2 e	2.98	1.02	0.003	0.000	0.321	0.012	0.622	0.021	0.003	4.98	63.7	1.3	32.9	2.1
I1	85L-11 5.1 c	2.97	1.02	0.006	0.000	0.320	0.011	0.626	0.032	0.004	4.99	63.3	1.1	32.4	3.2
I1	85L-11 5.2 c	2.98	1.02	0.005	0.000	0.317	0.011	0.630	0.023	0.004	4.99	64.2	1.1	32.3	2.4
I1	85L-11 5.3 c	3.00	1.00	0.005	0.000	0.320	0.011	0.624	0.019	0.003	4.98	64.1	1.1	32.9	1.9
I1	85L-11 5.4 c	2.98	1.01	0.005	0.000	0.326	0.012	0.637	0.016	0.003	4.99	64.3	1.2	32.9	1.6
I1	85L-11 6.1 c	2.98	1.02	0.004	0.000	0.317	0.011	0.635	0.023	0.002	4.99	64.4	1.1	32.2	2.3
I1	85L-11 6.2 e	2.98	1.02	0.004	0.000	0.317	0.010	0.633	0.016	0.003	4.98	64.8	1.0	32.5	1.6
I2	DAS87070 1.1 light	2.91	1.08	0.007	0.000	0.341	0.024	0.596	0.056	0.004	5.02	58.7	2.3	33.5	5.5
I2	DAS87070 1.2 dark (away from li	2.95	1.04	0.005	0.000	0.335	0.018	0.635	0.023	0.005	5.01	62.8	1.8	33.2	2.2
I2	DAS87070 2.1 small	2.95	1.04	0.004	0.000	0.253	0.011	0.698	0.034	0.006	5.00	70.1	1.1	25.4	3.4
I2	DAS87070 3.1 c	2.98	1.02	0.005	0.000	0.274	0.008	0.712	0.011	0.003	5.01	70.9	0.8	27.2	1.1
I2	DAS87070 3.2 e near light area	2.97	1.03	0.004	0.000	0.275	0.007	0.719	0.010	0.003	5.01	71.1	0.7	27.2	0.9
I2	DAS87070 3.3 light edge 1	2.96	1.03	0.004	0.000	0.270	0.009	0.709	0.023	0.004	5.01	70.1	0.9	26.7	2.3
I2	DAS87070 3.4 light edge 2	2.97	1.02	0.005	0.000	0.280	0.009	0.704	0.021	0.003	5.01	69.4	0.9	27.6	2.1
I2	DAS87070 4.1 c	2.96	1.03	0.005	0.000	0.253	0.010	0.688	0.036	0.004	4.99	69.7	1.0	25.6	3.7
I2	DAS87070 4.2 e	2.96	1.04	0.003	0.000	0.260	0.010	0.700	0.034	0.003	5.00	69.8	1.0	25.9	3.3
I2	DAS87070 5.1 c2	2.95	1.04	0.004	0.000	0.261	0.010	0.703	0.036	0.005	5.01	69.6	1.0	25.8	3.6
I2	DAS87070 5.2 c2	2.95	1.04	0.005	0.000	0.256	0.010	0.708	0.035	0.004	5.01	70.2	1.0	25.4	3.4
I3	DAS 89038 1.1 c	2.98	1.02	0.004	0.000	0.287	0.009	0.709	0.009	0.004	5.01	69.9	0.9	28.3	0.9
I3	DAS 89038 1.2 e	2.99	1.01	0.003	0.001	0.255	0.009	0.727	0.004	0.004	5.00	73.0	0.9	25.6	0.4
I3	DAS 89038 2.1 c dk half	2.97	1.03	0.004	0.000	0.267	0.011	0.702	0.017	0.005	5.00	70.5	1.1	26.8	1.7
I3	DAS 89038 2.2 lt half	2.96	1.04	0.004	0.000	0.276	0.011	0.683	0.029	0.007	5.00	68.4	1.1	27.7	2.9
I3	DAS 89038 3.1 c	2.95	1.04	0.006	0.000	0.293	0.012	0.686	0.028	0.004	5.02	67.4	1.2	28.7	2.7
I3	DAS 89038 3.2 c small grain (200	2.96	1.04	0.005	0.000	0.278	0.012	0.674	0.027	0.005	5.00	68.0	1.2	28.1	2.7
I3	DAS 89038 4.1 c	2.95	1.04	0.005	0.000	0.277	0.010	0.683	0.039	0.006	5.01	67.7	1.0	27.4	3.9
I3	DAS 89038 4.2 e	2.96	1.03	0.005	0.000	0.299	0.011	0.667	0.027	0.005	5.01	66.4	1.1	29.8	2.6
I3	DAS 89038 5.1 c	2.98	1.02	0.006	0.000	0.336	0.012	0.642	0.016	0.004	5.01	63.8	1.2	33.4	1.6
I3	DAS 89038 5.2 tip	2.98	1.02	0.005	0.000	0.303	0.011	0.657	0.017	0.001	4.99	66.5	1.1	30.7	1.7
I4	85S-110	2.96	1.04	0.004	0.000	0.260	0.010	0.680	0.033	0.000	4.99	69.2	1.0	26.4	3.4
I4	85S-110	2.96	1.04	0.004	0.000	0.277	0.009	0.666	0.033	0.000	4.99	67.6	0.9	28.1	3.4
I4	85S-110	2.96	1.04	0.005	0.000	0.271	0.009	0.659	0.033	0.000	4.98	67.8	1.0	27.8	3.4
I4	85S-110-2	2.98	1.02	0.004	0.000	0.278	0.007	0.670	0.016	0.000	4.98	69.0	0.8	28.6	1.6
I4	85S-110-2	3.00	1.01	0.002	0.000	0.276	0.008	0.658	0.011	0.000	4.98	69.0	0.8	29.0	1.2
I4	85S-110-2	3.00	0.99	0.004	0.000	0.262	0.007	0.695	0.016	0.000	4.98	70.9	0.8	26.7	1.6
I4	85S-110-3	3.01	0.99	0.005	0.000	0.274	0.008	0.678	0.000	0.000	4.97	70.6	0.9	28.5	0.0
I4	85S-110-3	3.00	1.00	0.004	0.000	0.267	0.006	0.686	0.011	0.000	4.97	70.7	0.6	27.6	1.1
I4	85S-110-4	2.97	1.03	0.004	0.000	0.273	0.010	0.662	0.033	0.000	4.98	67.7	1.0	27.9	3.4
I4	85S-110-4	2.96	1.04	0.004	0.000	0.278	0.009	0.660	0.030	0.000	4.98	67.6	1.0	28.4	3.0
I4	85S-110-5	2.96	1.04	0.003	0.000	0.287	0.010	0.661	0.033	0.000	4.99	66.7	1.0	29.0	3.3

Map ref.	Sample Name	Si	Al	Fe	Mg	Na	Ca	K	Ba	Sr	Total	Or	An	Ab	Cn
I4	85S-110-5	2.97	1.03	0.004	0.001	0.272	0.009	0.653	0.032	0.000	4.97	67.6	0.9	28.2	3.3
I4	85S-110-5	2.96	1.03	0.004	0.001	0.296	0.010	0.644	0.036	0.000	4.99	65.3	1.0	30.0	3.7
I5	DAS87042 badly pitted 1.2 c	2.95	1.04	0.005	0.000	0.353	0.012	0.606	0.028	0.004	5.00	60.7	1.2	35.4	2.8
I5	DAS87042 badly pitted 1.2 c	2.97	1.03	0.005	0.000	0.347	0.010	0.605	0.022	0.004	4.99	61.5	1.0	35.2	2.3
I5	DAS87042 badly pitted 2.1 c	2.97	1.02	0.005	0.000	0.274	0.011	0.678	0.027	0.006	4.99	68.5	1.1	27.7	2.8
I5	DAS87042 badly pitted 2.2 c	2.98	1.02	0.003	0.000	0.263	0.011	0.691	0.021	0.004	4.99	70.1	1.1	26.7	2.2
I5	DAS87042 badly pitted 3.1 c	2.96	1.04	0.005	0.000	0.325	0.011	0.634	0.034	0.006	5.01	63.2	1.1	32.3	3.4
I5	DAS87042 badly pitted 3.2 e	2.96	1.04	0.006	0.000	0.340	0.016	0.600	0.028	0.003	4.99	61.0	1.6	34.6	2.8
I5	DAS87042 badly pitted 4.1 e	2.96	1.03	0.006	0.001	0.341	0.012	0.603	0.039	0.005	5.00	60.6	1.2	34.3	4.0
I5	DAS87042 badly pitted 4.2 c	2.96	1.04	0.003	0.000	0.341	0.011	0.607	0.039	0.005	5.00	60.8	1.1	34.2	3.9
I5	DAS87042 badly pitted 5.1 c	2.97	1.02	0.005	0.000	0.316	0.011	0.647	0.028	0.005	5.00	64.6	1.1	31.5	2.7
I5	DAS87042 badly pitted 5.2 e	2.97	1.03	0.004	0.000	0.338	0.010	0.627	0.025	0.004	5.00	62.7	1.0	33.8	2.5
I6	DAS88011 1.1	2.97	1.02	0.006	0.000	0.325	0.010	0.670	0.010	0.002	5.02	66.0	1.0	32.0	1.0
I6	DAS88011 1.2 e	2.98	1.01	0.005	0.000	0.329	0.008	0.682	0.005	0.001	5.02	66.7	0.8	32.1	0.4
I6	DAS88011 2.1 c	2.98	1.01	0.006	0.000	0.325	0.008	0.680	0.008	0.002	5.02	66.6	0.8	31.8	0.7
I6	DAS88011 2.2 e	3.07	0.92	0.007	0.002	0.272	0.012	0.643	0.002	0.001	4.93	69.1	1.3	29.3	0.3
I6	DAS88011 3.1 c	2.97	1.02	0.004	0.001	0.277	0.010	0.733	0.010	0.004	5.03	71.2	0.9	26.9	1.0
I6	DAS88011 3.2 e	2.97	1.02	0.005	0.000	0.254	0.008	0.733	0.009	0.004	5.01	73.0	0.8	25.3	0.9
I6	DAS88011 4.1 c	2.96	1.03	0.006	0.000	0.359	0.025	0.624	0.012	0.003	5.02	61.2	2.4	35.2	1.2
I6	DAS88011 4.2 e	2.95	1.04	0.006	0.000	0.343	0.022	0.638	0.012	0.002	5.02	62.8	2.2	33.8	1.2
I6	DAS88011 5.1 c	2.94	1.05	0.005	0.000	0.265	0.011	0.712	0.034	0.004	5.02	69.7	1.0	26.0	3.3
I6	DAS88011 5.2 e	3.02	0.96	0.013	0.007	0.367	0.132	0.350	0.008	0.005	4.86	40.9	15.4	42.8	1.0
I7	DAS87063 1.1 c	2.95	1.04	0.005	0.000	0.333	0.013	0.631	0.026	0.003	5.01	63.0	1.3	33.2	2.6
I7	DAS87063 1.2	2.96	1.04	0.006	0.000	0.330	0.011	0.642	0.019	0.003	5.01	64.1	1.1	32.9	1.9
I7	DAS87063 1.3	2.98	1.00	0.005	0.000	0.334	0.011	0.654	0.015	0.002	5.01	64.5	1.0	33.0	1.5
I7	DAS87063 1.4	2.97	1.02	0.005	0.000	0.330	0.011	0.654	0.015	0.003	5.01	64.7	1.0	32.7	1.5
I7	DAS87063 2.1 c	2.94	1.05	0.006	0.000	0.332	0.014	0.624	0.036	0.003	5.01	62.0	1.4	33.0	3.6
I7	DAS87063 2.2	2.96	1.03	0.005	0.000	0.323	0.010	0.641	0.027	0.002	5.00	64.0	1.0	32.3	2.7
I7	DAS87063 2.3	2.97	1.02	0.005	0.000	0.334	0.010	0.641	0.016	0.003	5.00	64.0	1.0	33.4	1.6
I7	DAS87063 2.4 e	2.96	1.03	0.004	0.000	0.322	0.012	0.642	0.023	0.004	5.00	64.3	1.2	32.2	2.3
I7	DAS87063 3.1 c	2.95	1.05	0.006	0.000	0.343	0.011	0.638	0.027	0.003	5.02	62.6	1.0	33.7	2.7
I7	DAS87063 3.2 e	2.97	1.03	0.004	0.000	0.331	0.012	0.634	0.019	0.002	5.00	63.7	1.2	33.2	1.9
I7	DAS87063 4.1 c	2.96	1.04	0.004	0.000	0.334	0.012	0.625	0.030	0.003	5.00	62.4	1.2	33.4	3.0
I7	DAS87063 4.2 m	2.94	1.05	0.005	0.000	0.341	0.015	0.614	0.034	0.004	5.01	61.2	1.5	34.0	3.4
I7	DAS87063 4.3 e	2.96	1.05	0.005	0.000	0.335	0.014	0.608	0.024	0.003	4.99	62.0	1.4	34.1	2.4
I7	DAS87063 5.1 c	2.95	1.04	0.005	0.000	0.379	0.016	0.597	0.028	0.002	5.02	58.6	1.5	37.2	2.8
I7	DAS87063 5.2	2.97	1.03	0.004	0.000	0.358	0.012	0.613	0.019	0.003	5.01	61.2	1.2	35.7	1.9
I7	DAS87063 5.3 light patch (rim)	2.90	1.09	0.008	0.000	0.355	0.020	0.568	0.064	0.008	5.01	56.4	2.0	35.2	6.4
I7	DAS87063 6.1	2.95	1.04	0.005	0.000	0.341	0.014	0.625	0.031	0.003	5.01	61.9	1.3	33.7	3.0
I7	DAS87063 6.2 e	2.96	1.03	0.005	0.000	0.326	0.011	0.649	0.015	0.003	5.01	64.8	1.1	32.6	1.5
I7	DAS87063 7.1 c	2.97	1.03	0.006	0.000	0.332	0.011	0.636	0.021	0.002	5.00	63.6	1.1	33.2	2.1
I7	DAS87063 7.2 e	2.97	1.02	0.005	0.000	0.331	0.011	0.650	0.016	0.003	5.01	64.4	1.1	32.9	1.6
I7	DAS87063 8.1 c	2.97	1.02	0.004	0.000	0.338	0.011	0.653	0.008	0.000	5.01	64.7	1.0	33.4	0.8

Map ref.	Sample Name	Si	Al	Fe	Mg	Na	Ca	K	Ba	Sr	Total	Or	An	Ab	Cn
I7	DAS87063 8.1 e	2.97	1.02	0.005	0.000	0.342	0.010	0.656	0.009	0.002	5.02	64.5	1.0	33.6	0.9
I7	DAS87063 9	2.96	1.03	0.006	0.000	0.329	0.012	0.636	0.021	0.003	5.00	63.7	1.2	33.0	2.1
Average		**2.97**	**1.03**	**0.005**	**0.000**	**0.309**	**0.013**	**0.650**	**0.023**	**0.003**	**5.00**	**65.3**	**1.3**	**31.1**	**2.3**
Sigma		**0.02**	**0.02**	**0.001**	**0.001**	**0.033**	**0.013**	**0.048**	**0.011**	**0.002**	**0.02**	**4.4**	**1.5**	**3.4**	**1.1**

Snowshoe Mountain Tuff		Si	Al	Fe	Mg	Na	Ca	K	Ba	Sr	Total	Or	An	Ab	Cn
S1	C8-71-4 lg san	2.97	1.03	0.004	0.000	0.240	0.009	0.690	0.029	0.000	4.98	71.3	0.9	24.8	3.0
S1	C8-71-4 lg san	2.96	1.04	0.003	0.000	0.244	0.010	0.694	0.026	0.000	4.98	71.3	1.0	25.0	2.7
S1	C8-71-4 cluster	2.97	1.03	0.005	0.000	0.252	0.008	0.696	0.021	0.000	4.98	71.2	0.8	25.8	2.1
S1	C8-71-4 cluster	2.98	1.02	0.003	0.000	0.241	0.008	0.712	0.019	0.000	4.98	72.7	0.8	24.6	2.0
S1	C8-71-4 cluster	2.99	1.01	0.004	0.000	0.235	0.008	0.700	0.025	0.000	4.97	72.3	0.9	24.2	2.6
S1	C8-71-4 cluster	2.98	1.03	0.003	0.000	0.255	0.009	0.678	0.023	0.000	4.97	70.3	0.9	26.4	2.3
S1	C8-71-4 cluster	2.98	1.03	0.005	0.000	0.251	0.009	0.688	0.024	0.000	4.98	70.8	0.9	25.9	2.4
S1	C8-71-4 small gr edge 2/5/93	3.01	1.00	0.004	0.000	0.234	0.009	0.698	0.016	0.000	4.96	72.9	1.0	24.5	1.7
S1	C8-71-4 small gr edge 2/5/93	3.00	1.00	0.005	0.000	0.255	0.008	0.676	0.019	0.000	4.96	70.6	0.8	26.6	1.9
S2	C6-11-7-1sm	2.96	1.04	0.006	0.000	0.283	0.010	0.662	0.034	0.000	4.99	67.0	1.0	28.6	3.4
S2	C6-11-7-2sm	2.97	1.03	0.005	0.000	0.274	0.007	0.682	0.023	0.000	4.99	69.2	0.7	27.7	2.4
S2	C6-11-7-3sm	2.97	1.03	0.004	0.000	0.280	0.008	0.699	0.013	0.000	5.00	69.9	0.8	27.9	1.3
S2	C6-11-7-4sm	2.96	1.04	0.005	0.000	0.274	0.011	0.671	0.024	0.000	4.99	68.5	1.1	27.9	2.4
S2	C6-11-7 top of slide, center	2.96	1.05	0.005	0.000	0.245	0.011	0.682	0.033	0.000	4.96	70.3	1.1	25.2	3.4
S2	C6-11-7 top of slide, edge	2.96	1.04	0.005	0.000	0.250	0.010	0.677	0.036	0.000	4.98	69.6	1.0	25.7	3.7
S2	C6-11-7 1of3 2/5/93	2.97	1.03	0.005	0.001	0.222	0.009	0.717	0.031	0.000	4.98	73.3	0.9	22.6	3.2
S2	C6-11-7 2of3 2/5/93	2.97	1.03	0.005	0.000	0.237	0.011	0.679	0.036	0.000	4.97	70.5	1.1	24.6	3.7
S2	C6-11-7 3of3 2/5/93	2.99	1.00	0.005	0.000	0.249	0.010	0.683	0.034	0.000	4.97	70.0	1.0	25.5	3.5
S2	C6-11-7 edge of slide 2/5/93	2.94	1.06	0.004	0.000	0.258	0.011	0.718	0.022	0.000	5.01	71.1	1.1	25.6	2.2
S2	C6-11-7 edge of slide 2/5/93	2.91	1.09	0.005	0.000	0.258	0.011	0.730	0.031	0.000	5.04	70.9	1.1	25.0	3.0
S2	C6-11-7 edge of slide 2/5/93	2.96	1.04	0.005	0.000	0.243	0.011	0.689	0.038	0.000	4.98	70.3	1.1	24.8	3.9
S2	C6-11-7 edge of slide 2/5/93	2.96	1.04	0.005	0.000	0.257	0.011	0.679	0.037	0.000	4.99	69.0	1.1	26.1	3.7
S3	C6-8-30A middle, center	2.96	1.03	0.006	0.000	0.267	0.008	0.690	0.031	0.000	5.00	69.3	0.8	26.8	3.1
S3	C6-8-30A middle, edge	2.98	1.02	0.004	0.000	0.245	0.008	0.720	0.011	0.000	4.99	73.1	0.8	24.9	1.1
S3	C6-8-30A-1c	2.97	1.03	0.005	0.001	0.261	0.009	0.701	0.021	0.000	5.00	70.6	0.9	26.3	2.1
S3	C6-8-30A-1r	2.96	1.03	0.005	0.000	0.240	0.011	0.711	0.024	0.000	4.99	72.1	1.1	24.4	2.4
S3	C6-8-30A-2c	2.95	1.05	0.003	0.000	0.243	0.010	0.698	0.032	0.000	4.99	71.0	1.0	24.7	3.3
S3	C6-8-30A-2r	2.96	1.04	0.003	0.000	0.247	0.011	0.701	0.027	0.000	4.99	71.1	1.1	25.1	2.7
S4	DAS87-104b	2.96	1.05	0.005	0.001	0.255	0.009	0.654	0.031	0.000	4.97	68.9	0.9	26.9	3.3
S4	DAS87-104b edge	2.98	1.03	0.004	0.000	0.252	0.009	0.659	0.024	0.002	4.98	69.8	1.0	26.7	2.6
S4	DAS87-104b 2.1	2.96	1.05	0.006	0.000	0.259	0.010	0.666	0.035	0.000	4.98	68.7	1.1	26.7	3.6
S4	DAS87-104b 2.2 edge	2.96	1.05	0.006	0.000	0.250	0.013	0.674	0.030	0.000	4.98	69.7	1.3	25.9	3.1
S4	DAS87-104b 3.1	2.98	1.04	0.006	0.000	0.234	0.012	0.691	0.031	0.001	4.98	71.4	1.2	24.2	3.2
S4	DAS87-104b 3.2	2.95	1.05	0.005	0.000	0.242	0.012	0.692	0.037	0.001	4.99	70.4	1.2	24.6	3.8
S5	87L-41-1c	2.98	1.01	0.004	0.000	0.282	0.008	0.683	0.014	0.000	4.99	69.2	0.8	28.6	1.4
S5	87L-41-1r	2.96	1.05	0.004	0.000	0.280	0.010	0.672	0.025	0.000	4.99	68.1	1.1	28.4	2.5
S5	87L-41-2c	2.99	1.01	0.004	0.000	0.285	0.008	0.679	0.010	0.000	4.99	69.2	0.9	29.0	1.0

Map ref.	Sample Name	Si	Al	Fe	Mg	Na	Ca	K	Ba	Sr	Total	Or	An	Ab	Cn
S5	87L-41-2r	2.99	1.01	0.005	0.000	0.267	0.009	0.682	0.013	0.000	4.98	70.2	0.9	27.5	1.4
S5	87L-41-3c bad polish	2.98	1.03	0.003	0.000	0.281	0.008	0.689	0.014	0.000	5.00	69.5	0.8	28.3	1.4
S5	87L-41-3r bad polish, zoned	2.96	1.04	0.004	0.000	0.273	0.009	0.672	0.028	0.000	4.99	68.4	0.9	27.8	2.9
S5	87L-41-3m bad polish, zoned	2.95	1.04	0.004	0.000	0.298	0.010	0.667	0.026	0.000	5.00	66.6	1.0	29.8	2.6
S5	87L-41-4r bad polish	2.97	1.04	0.005	0.000	0.269	0.009	0.663	0.027	0.000	4.98	68.5	0.9	27.8	2.8
S5	87L-41-5c bad polish	2.99	1.01	0.005	0.000	0.279	0.007	0.669	0.011	0.000	4.97	69.3	0.7	28.9	1.1
S5	87L-41-5r bad polish	2.98	1.03	0.004	0.000	0.282	0.007	0.682	0.015	0.000	4.99	69.1	0.7	28.6	1.5
S5	87L-41-4c bad polish	2.96	1.05	0.005	0.000	0.264	0.009	0.680	0.026	0.000	4.99	69.5	0.9	27.0	2.6
S5	87L-41-6r bad polish	2.96	1.04	0.007	0.001	0.274	0.007	0.666	0.028	0.000	4.98	68.3	0.7	28.1	2.9
S5	87L-41-6c bad polish	2.97	1.03	0.005	0.000	0.263	0.008	0.675	0.024	0.000	4.98	69.6	0.8	27.2	2.4
S5	87L-41-7c	2.97	1.03	0.004	0.000	0.286	0.012	0.671	0.010	0.000	4.99	68.6	1.2	29.3	1.0
S5	87L-41-7r	2.98	1.02	0.008	0.001	0.284	0.009	0.687	0.005	0.000	4.99	69.8	0.9	28.9	0.5
S5	87L-41-8c	2.96	1.03	0.004	0.000	0.277	0.010	0.681	0.011	0.000	4.99	69.6	1.0	28.3	1.1
S5	87L-41-8r	2.98	1.02	0.004	0.000	0.292	0.010	0.669	0.015	0.000	4.99	67.9	1.0	29.6	1.5
S5	87L-41-8r	2.98	1.02	0.006	0.000	0.277	0.008	0.677	0.026	0.000	4.99	68.6	0.8	28.0	2.6
S5	87L-41-9c	2.97	1.03	0.004	0.000	0.284	0.011	0.664	0.023	0.000	4.99	67.6	1.1	28.9	2.3
S5	87L-41-9r	2.98	1.02	0.005	0.000	0.281	0.007	0.692	0.010	0.000	5.00	69.9	0.7	28.4	1.0
S6	69L12 1.1	2.97	1.03	0.004	0.000	0.248	0.011	0.690	0.027	0.001	4.98	70.7	1.1	25.4	2.7
S6	69L12 1.2	2.97	1.04	0.004	0.000	0.260	0.011	0.675	0.029	0.000	4.98	69.3	1.1	26.7	2.9
S6	69L12 2.1	2.97	1.04	0.005	0.000	0.249	0.009	0.662	0.030	0.000	4.96	69.7	1.0	26.2	3.2
S6	69L12 2.2	2.96	1.05	0.004	0.000	0.257	0.010	0.679	0.023	0.000	4.98	70.1	1.0	26.5	2.4
S6	69L12 3.1	2.95	1.05	0.003	0.000	0.255	0.011	0.702	0.023	0.000	5.00	70.8	1.1	25.7	2.3
S6	69L12 3.2	2.98	1.03	0.004	0.000	0.251	0.008	0.682	0.017	0.000	4.97	71.2	0.8	26.2	1.8
S6	69L12 4.1	2.94	1.06	0.004	0.000	0.318	0.012	0.644	0.024	0.000	5.01	64.5	1.2	31.9	2.4
S6	69L12 4.2	2.96	1.04	0.003	0.000	0.321	0.012	0.632	0.023	0.000	4.99	63.9	1.3	32.5	2.3
S6	69L12 5.1	2.98	1.02	0.004	0.000	0.309	0.006	0.670	0.008	0.000	5.00	67.4	0.6	31.1	0.8
S6	69L12 5.2	2.99	1.02	0.004	0.000	0.300	0.008	0.657	0.007	0.000	4.98	67.6	0.8	30.9	0.7
Average		**2.97**	**1.03**	**0.005**	**0.000**	**0.264**	0.009	**0.682**	**0.023**	**0.000**	**4.99**	**69.7**	**1.0**	**26.9**	**2.4**
Sigma		**0.02**	**0.02**	**0.001**	**0.000**	**0.021**	0.002	**0.018**	**0.008**	**0.000**	**0.01**	**1.8**	**0.2**	**2.0**	**0.9**

Drill Core Samples		Si	Al	Fe	Mg	Na	Ca	K	Ba	Sr	Total	Or	An	Ab	Cn
D1	2R237_1.75A 1.1 c	2.96	1.04	0.004	0.000	0.247	0.014	0.697	0.029	0.006	4.99	70.6	1.4	25.1	2.9
D1	2R237_1.75A 1.2 e	2.97	1.03	0.005	0.000	0.248	0.012	0.711	0.020	0.005	5.00	71.8	1.2	25.0	2.0
D1	2R237_1.75A 2.1 c	2.97	1.02	0.005	0.000	0.248	0.010	0.695	0.027	0.004	4.99	71.0	1.0	25.3	2.7
D1	2R237_1.75A 2.2 e	2.97	1.02	0.003	0.000	0.245	0.012	0.710	0.019	0.005	4.99	72.0	1.2	24.9	1.9
D1	2R237_1.75A 3.1 c	2.94	1.06	0.004	0.000	0.247	0.011	0.694	0.035	0.005	5.00	70.3	1.1	25.1	3.5
D1	2R237_1.75A 3.2 e	2.96	1.04	0.004	0.000	0.249	0.011	0.703	0.026	0.004	5.00	71.1	1.1	25.2	2.7
D1	2R237_1.75A 4.1 c	2.96	1.04	0.003	0.000	0.248	0.010	0.705	0.030	0.005	5.00	71.0	1.0	24.9	3.0
D1	2R237_1.75A 4.2 e	2.98	1.04	0.004	0.000	0.244	0.011	0.702	0.028	0.005	4.99	71.3	1.1	24.8	2.8
D1	2R237_1.75A 5.1 sm	2.96	1.01	0.004	0.000	0.259	0.009	0.699	0.019	0.003	4.99	70.9	1.0	26.3	1.9
D1	2R237_1.75A 6.1 c	2.97	1.04	0.004	0.000	0.247	0.010	0.680	0.019	0.003	4.97	71.1	1.0	25.9	2.0
D1	2R237_1.75A 6.2 e	2.95	1.05	0.004	0.000	0.250	0.011	0.722	0.023	0.004	5.01	71.8	1.0	24.9	2.3
D2	2R220_A6.6B center lg grain	2.99	1.01	0.004	0.000	0.234	0.011	0.698	0.020	0.000	4.97	72.5	1.1	24.3	2.1

Map ref.	Sample Name	Si	Al	Fe	Mg	Na	Ca	K	Ba	Sr	Total	Or	An	Ab	Cn
D2	2R220_A6.6B edge lg grain	2.98	1.03	0.004	0.000	0.247	0.011	0.693	0.017	0.000	4.98	71.6	1.1	25.5	1.8
D2	2R220_A6.6B center sm grain	2.99	1.02	0.003	0.000	0.236	0.010	0.698	0.018	0.000	4.97	72.5	1.0	24.5	1.9
D2	2R220_A6.6B edge sm grain	2.98	1.02	0.004	0.000	0.255	0.010	0.686	0.018	0.000	4.98	70.8	1.0	26.3	1.9
D2	2R220-A6.6B below notch 2/5/93	2.97	1.03	0.006	0.000	0.248	0.013	0.683	0.030	0.000	4.98	70.2	1.3	25.5	3.0
D2	2R220-A6.6B below notch 2/5/93	2.99	1.00	0.005	0.000	0.242	0.008	0.691	0.028	0.000	4.97	71.3	0.8	24.9	2.9
D2	2R220-A6.6B below notch 2/5/93	2.99	1.01	0.005	0.000	0.245	0.009	0.682	0.029	0.000	4.97	70.7	0.9	25.4	3.0
D2	2R220-A6.6B below notch 2/5/93	2.97	1.03	0.003	0.000	0.239	0.008	0.689	0.033	0.000	4.98	71.1	0.9	24.6	3.4
D2	2R220-A6.6B below notch 2/5/93	2.98	1.01	0.006	0.000	0.243	0.010	0.685	0.033	0.000	4.97	70.6	1.0	25.0	3.4
D2	2R220-A6.6B below notch 2/5/93	2.97	1.03	0.005	0.000	0.232	0.009	0.684	0.038	0.000	4.97	71.1	0.9	24.1	3.9
D2	2R220-A6.6B below notch 2/5/93	2.98	1.02	0.006	0.000	0.229	0.009	0.686	0.035	0.000	4.97	71.5	1.0	23.9	3.7
D2	2R220-A6.6B below notch 2/5/93	2.99	1.01	0.004	0.000	0.237	0.011	0.699	0.017	0.000	4.97	72.5	1.1	24.6	1.8
D2	2R220-A6.6B below notch 2/5/93	2.99	1.01	0.004	0.000	0.247	0.011	0.696	0.016	0.000	4.97	71.8	1.1	25.5	1.6
D3	2R207-2.4A 1.1 c	2.91	1.09	0.007	0.000	0.321	0.022	0.597	0.059	0.006	5.01	59.8	2.2	32.1	5.9
D3	2R207-2.4A 1.2 e	2.94	1.05	0.005	0.000	0.318	0.018	0.611	0.047	0.005	5.00	61.5	1.8	32.0	4.7
D3	2R207-2.4A 2.1 sm	2.96	1.04	0.004	0.000	0.247	0.011	0.704	0.027	0.005	5.00	71.2	1.2	24.9	2.7
D3	2R207-2.4A 3.1 c	2.98	1.02	0.003	0.001	0.336	0.013	0.595	0.015	0.003	4.97	62.1	1.3	35.0	1.6
D3	2R207-2.4A 3.2 e	2.98	1.02	0.006	0.000	0.337	0.012	0.614	0.013	0.003	4.99	62.9	1.2	34.5	1.3
D3	2R207-2.4A 4.1 sm	2.95	1.05	0.004	0.000	0.237	0.011	0.697	0.035	0.004	4.99	71.1	1.1	24.2	3.6
D4	2R207-2.4A "clast" 1.1 c	2.93	1.06	0.007	0.000	0.310	0.018	0.634	0.038	0.004	5.01	63.4	1.8	31.0	3.8
D4	2R207-2.4A "clast" 1.2 e	2.91	1.09	0.009	0.000	0.320	0.019	0.640	0.035	0.005	5.03	63.1	1.9	31.6	3.4
Average		**2.97**	**1.03**	**0.005**	**0.000**	**0.259**	**0.012**	**0.681**	**0.027**	**0.003**	**4.99**	**69.6**	**1.2**	**26.5**	**2.8**
Sigma		**0.02**	**0.02**	**0.001**	**0.000**	**0.032**	**0.003**	**0.033**	**0.010**	**0.002**	**0.02**	**3.7**	**0.3**	**3.1**	**1.0**
Average no clast		**2.97**	**1.03**	**0.004**	**0.000**	**0.255**	**0.011**	**0.684**	**0.027**	**0.003**	**4.98**	**70.0**	**1.1**	**26.1**	**2.7**
Sigma no clast		**0.02**	**0.02**	**0.001**	**0.000**	**0.030**	**0.003**	**0.033**	**0.010**	**0.002**	**0.01**	**3.4**	**0.3**	**3.0**	**1.0**

Bulldog Mine		Si	Al	Fe	Mg	Na	Ca	K	Ba	Sr	Total	Or	An	Ab	Cn
B1	BM 47 c 435 1.1 c	2.97	1.03	0.004	0.000	0.301	0.009	0.640	0.032	0.004	4.99	65.1	0.9	30.7	3.3
B1	BM 47 c 435 1.2 e	2.97	1.02	0.003	0.000	0.317	0.009	0.623	0.038	0.004	4.99	63.2	0.9	32.1	3.8
B1	BM 47 c 435 2.1 patchy--bright	2.96	1.03	0.005	0.001	0.336	0.013	0.612	0.039	0.003	5.00	61.2	1.3	33.6	3.9
B1	BM 47 c 435 2.2 patchy--bright	2.95	1.05	0.004	0.000	0.344	0.013	0.609	0.038	0.003	5.01	60.7	1.3	34.3	3.8
B1	BM 47 c 435 3.1 c	2.93	1.07	0.005	0.000	0.338	0.013	0.625	0.030	0.003	5.02	62.1	1.3	33.6	3.0
B1	BM 47 c 435 3.2 c	2.95	1.05	0.006	0.001	0.332	0.013	0.624	0.036	0.005	5.01	62.1	1.3	33.1	3.5
B1	BM 47 c 435 3.3 c	2.94	1.06	0.003	0.000	0.338	0.014	0.625	0.044	0.003	5.02	61.2	1.4	33.1	4.3
B1	BM 47 c 435 3.4 c	2.96	1.04	0.006	0.000	0.325	0.016	0.610	0.038	0.004	4.99	61.7	1.6	32.8	3.9
B1	BM 47 c 435 3.5 c	2.96	1.04	0.007	0.001	0.300	0.011	0.661	0.022	0.004	5.00	66.5	1.1	30.2	2.2
B1	BM 47 c 435 4.1 c	2.97	1.03	0.005	0.001	0.331	0.013	0.615	0.026	0.003	4.99	62.5	1.3	33.6	2.6
B1	BM 47 c 435 4.3 c	2.97	1.03	0.004	0.000	0.335	0.010	0.601	0.031	0.004	4.98	61.5	1.1	34.3	3.1
B1	BM 47 c 435 4.3 c	2.98	1.01	0.004	0.000	0.328	0.011	0.626	0.023	0.003	4.99	63.4	1.1	33.2	2.3
B1	BM 47 c 435 4.5 c	2.98	1.02	0.004	0.000	0.328	0.010	0.639	0.017	0.003	5.00	64.3	1.0	33.0	1.7
B1	BM 47 c 435 5.1 c	2.95	1.05	0.005	0.000	0.306	0.010	0.634	0.040	0.004	5.00	64.0	1.0	30.9	4.0
B1	BM 47 c 435 5.2 c	2.96	1.04	0.005	0.000	0.299	0.010	0.639	0.038	0.005	4.99	64.8	1.0	30.3	3.9
B2	BM36 c 85' 1.1 c	2.96	1.02	0.005	0.000	0.322	0.010	0.601	0.028	0.004	4.97	62.5	1.1	33.5	3.0
B2	BM36 c 85' 1.2 e	2.96	1.02	0.005	0.000	0.327	0.011	0.612	0.022	0.002	4.98	63.0	1.1	33.6	2.3

Map ref.	Sample Name	Si	Al	Fe	Mg	Na	Ca	K	Ba	Sr	Total	Or	An	Ab	Cn
B2	BM36 c 85' patchy zoning c	2.96	1.04	0.004	0.000	0.342	0.011	0.628	0.018	0.003	5.00	62.8	1.1	34.3	1.8
B2	BM36 c 85' patchy zoning e	2.99	1.01	0.005	0.000	0.332	0.009	0.634	0.015	0.003	4.99	64.0	0.9	33.6	1.5
B2	BM36 c 85' 3.1 patxichy zoning	2.96	1.02	0.005	0.000	0.332	0.011	0.630	0.016	0.001	4.99	63.7	1.1	33.6	1.6
B2	BM36 c 85' 3.2 patxichy zoning	2.99	1.01	0.006	0.000	0.339	0.011	0.600	0.017	0.002	4.97	62.1	1.1	35.0	1.8
B2	BM36 c 85' 3.3 patxichy zoning	2.97	1.03	0.005	0.000	0.338	0.011	0.607	0.023	0.002	4.99	62.0	1.1	34.5	2.4
B2	BM36 c 85' 4.1	2.96	1.04	0.005	0.000	0.338	0.013	0.596	0.033	0.003	4.99	60.8	1.3	34.5	3.4
B2	BM36 c 85' 4.2	2.94	1.05	0.005	0.000	0.344	0.014	0.597	0.043	0.006	5.00	59.8	1.4	34.5	4.3
B2	BM36 c 85' 5.1	2.95	1.05	0.006	0.000	0.332	0.014	0.565	0.046	0.003	4.97	59.0	1.4	34.7	4.8
B2	BM36 c 85' 5.2	2.94	1.06	0.005	0.000	0.350	0.018	0.557	0.045	0.004	4.98	57.4	1.9	36.1	4.6
Average		**2.96**	**1.03**	**0.005**	**0.000**	**0.329**	**0.012**	**0.616**	**0.031**	**0.003**	**4.99**	**62.4**	**1.2**	**33.3**	**3.1**
Sigma		**0.02**	**0.02**	**0.001**	**0.000**	**0.014**	**0.002**	**0.022**	**0.010**	**0.001**	**0.01**	**1.9**	**0.2**	**1.4**	**1.0**

McDonough Reservoir Sample		Si	Al	Fe	Mg	Na	Ca	K	Ba	Sr	Total	Or	An	Ab	Cn
M	85L-36 1.1	2.96	1.05	0.005	0.000	0.253	0.012	0.686	0.025	0.001	4.99	70.3	1.2	25.9	2.6
M	85L-36 1.2	2.97	1.03	0.004	0.000	0.252	0.011	0.692	0.016	0.000	4.98	71.3	1.1	26.0	1.6
M	85L-36 2.1	2.96	1.05	0.003	0.000	0.253	0.012	0.680	0.025	0.000	4.98	70.1	1.2	26.1	2.6
M	85L-36 2.2	2.96	1.04	0.004	0.000	0.261	0.011	0.681	0.025	0.001	4.99	69.7	1.1	26.7	2.5
M	85L-36 3.1	2.95	1.05	0.006	0.000	0.350	0.011	0.591	0.027	0.000	4.99	60.3	1.2	35.8	2.7
M	85L-36 4.1	2.96	1.04	0.007	0.000	0.314	0.014	0.613	0.035	0.001	4.98	62.9	1.4	32.2	3.5
M	85L-36 4.2	2.96	1.04	0.007	0.000	0.316	0.015	0.613	0.031	0.001	4.98	62.9	1.6	32.4	3.2
M	85L-36 5.1	2.95	1.05	0.009	0.000	0.425	0.026	0.507	0.028	0.000	4.99	51.5	2.6	43.1	2.8
M	85L-36 6.1	2.95	1.05	0.005	0.000	0.282	0.011	0.665	0.026	0.000	4.99	67.6	1.1	28.7	2.6
Average		**2.96**	**1.04**	**0.005**	**0.000**	**0.301**	**0.014**	**0.636**	**0.026**	**0.001**	**4.99**	**65.2**	**1.4**	**30.8**	**2.7**
Sigma		**0.01**	**0.01**	**0.002**	**0.000**	**0.058**	**0.005**	**0.061**	**0.005**	**0.001**	**0.00**	**6.5**	**0.5**	**5.8**	**0.5**

Appendix 2A. Individual point analyses, hornblende phenocrysts, cations

Snowshoe Mountain Tuff							Cations, oxygen = 24						
Map Reference	Comment	Si	Al	Ti	Na	Fe	Mg	Mn	Ca	K	Cl	F	Total
S1	C8-71-4 1.1	7.13	1.38	0.198	0.443	1.80	3.14	0.081	1.96	0.164	0.024	0.075	16.39
S1	C8-71-4 1.2	7.18	1.39	0.181	0.399	1.73	3.17	0.079	1.94	0.154	0.028	0.085	16.34
S1	C8-71-4 2.1 sm	7.13	1.44	0.199	0.456	1.68	3.19	0.081	1.92	0.170	0.027	0.072	16.37
S1	C8-71-4 3.1 c	7.01	1.56	0.235	0.512	1.79	3.04	0.096	1.92	0.168	0.028	0.099	16.45
S1	C8-71-4 3.2 e	7.26	1.25	0.161	0.373	1.70	3.28	0.082	1.97	0.136	0.024	0.073	16.31
S1	C8-71-4 4.2 tip	7.28	1.25	0.157	0.405	1.73	3.20	0.086	1.97	0.141	0.026	0.057	16.29
S1	C8-71-4 4.1 c	7.20	1.32	0.152	0.415	1.77	3.24	0.092	1.92	0.159	0.027	0.073	16.38
S1	C8-71-4 5.1 c	7.36	1.18	0.145	0.385	1.64	3.32	0.087	1.91	0.130	0.022	0.071	16.25
S1	C8-71-4 5.2 e	7.24	1.29	0.152	0.391	1.76	3.24	0.085	1.94	0.148	0.023	0.035	16.30
S1	C8-71-4 6.1	7.01	1.62	0.196	0.452	1.90	2.92	0.079	1.93	0.208	0.036	0.034	16.38
S1	C8-71-4 6.2	6.99	1.57	0.191	0.453	1.94	3.00	0.084	1.94	0.194	0.034	0.013	16.41
S1	C8-71-4 6.3 e	7.04	1.56	0.192	0.472	1.91	2.90	0.092	1.95	0.209	0.034	0.027	16.39
S2	C6-11-7 grain1 pt 1/5	7.00	1.58	0.197	0.501	1.85	2.99	0.082	1.96	0.210	0.038	0.158	16.57
S2	C-6-11-7 gr1 pt2/6	6.86	1.71	0.253	0.526	1.94	2.88	0.076	1.95	0.201	0.028	0.139	16.56
S2	C-6-11-7 gr1 pt4/8	6.93	1.65	0.205	0.488	1.98	2.89	0.085	1.95	0.220	0.040	0.140	16.57
S2	C-6-11-7 gr2 pt5/8	6.96	1.61	0.195	0.497	1.91	3.01	0.087	1.93	0.196	0.033	0.173	16.59
S2	C-6-11-7 gr2 pt6/9	7.04	1.53	0.195	0.465	1.89	2.97	0.084	1.96	0.198	0.035	0.136	16.50
S2	C-6-11-7 gr3 pt7/11	7.25	1.38	0.177	0.443	1.69	3.07	0.082	1.95	0.148	0.030	0.166	16.38
S2	C-6-11-7 gr3 pt8/12	7.16	1.39	0.169	0.452	1.73	3.21	0.086	1.92	0.163	0.033	0.160	16.47
S3	C6-8-30A gr1 pt 1/17	7.05	1.49	0.193	0.436	1.78	3.15	0.091	1.94	0.177	0.032	0.144	16.49
S3	C6-8-30A gr1 pt 3/19	7.09	1.49	0.196	0.452	1.75	3.13	0.080	1.92	0.179	0.035	0.151	16.47
S3	C6-8-30A gr1 pt 2/18	7.09	1.45	0.191	0.416	1.75	3.21	0.076	1.92	0.178	0.027	0.174	16.49
S3	C6-8-30A gr3 pt 1/20	7.10	1.46	0.194	0.439	1.71	3.18	0.079	1.94	0.172	0.028	0.148	16.45
S3	C6-8-30A gr3 pt 1/21	7.10	1.53	0.206	0.432	1.64	3.13	0.085	1.94	0.164	0.019	0.149	16.40
S3	C6-8-30A gr4 pt 1/22	7.24	1.31	0.164	0.396	1.67	3.26	0.084	1.93	0.156	0.023	0.114	16.35
S3	C6-8-30A gr5 pt 1/23	7.22	1.35	0.173	0.386	1.69	3.22	0.085	1.92	0.148	0.027	0.155	16.38
S3	C6-8-30A gr5 pt 2/24	7.19	1.37	0.156	0.407	1.74	3.23	0.087	1.91	0.158	0.030	0.131	16.41
S3	C6-8-30A gr6 new grain	6.88	1.76	0.229	0.501	1.79	3.02	0.088	1.89	0.182	0.018	0.117	16.48
S3	C6-8-30A gr6 new grain	6.78	1.84	0.230	0.534	1.84	2.99	0.091	1.94	0.199	0.023	0.155	16.62
S5	87C-41gr1 115	7.49	1.02	0.124	0.381	1.54	3.38	0.133	1.94	0.108	0.012	0.206	16.34
S5	87C-41gr1 115	7.47	1.07	0.128	0.399	1.52	3.40	0.128	1.88	0.112	0.015	0.220	16.35
S5	87C-41gr2 82,83,84	7.39	1.06	0.121	0.387	1.61	3.43	0.116	1.98	0.108	0.015	0.219	16.44
S5	87C-41gr2 82,83,84	7.53	0.96	0.106	0.333	1.52	3.52	0.123	1.91	0.100	0.013	0.209	16.32
S5	87C-41gr2 82,83,84	7.52	0.94	0.111	0.401	1.54	3.47	0.119	1.95	0.106	0.018	0.196	16.37
S5	87C-41gr3 86	6.93	1.61	0.232	0.604	1.59	3.23	0.088	1.96	0.163	0.019	0.198	16.63

Nelson Mountain Tuff

Map Reference	Comment	Si	Al	Ti	Na	Fe	Mg	Mn	Ca	K	Cl	F	Total
N1	C5-6-14 w/in clast	6.67	2.00	0.267	0.618	1.82	3.02	0.079	1.82	0.144	0.012	0.155	16.61
N1	C5-6-14 w/in clast	6.99	1.61	0.206	0.508	1.84	3.01	0.081	1.93	0.182	0.026	0.137	16.51
N1	C5-6-14 "4" from 2/23/93	6.33	2.31	0.391	0.674	1.45	3.28	0.020	1.91	0.200	0.009	0.171	16.74
N1	C5-6-14 "4" from 2/23/93	6.36	2.30	0.403	0.676	1.38	3.28	0.021	1.90	0.205	0.003	0.166	16.69
N6	93L-2B 2.1 c	7.30	1.20	0.142	0.383	1.69	3.35	0.093	1.92	0.126	0.019	0.063	16.29
N6	93L-2B 2.2 e	7.32	1.20	0.130	0.357	1.67	3.35	0.068	1.97	0.138	0.019	0.112	16.33
N6	93L-2B 3.1 c	7.26	1.20	0.139	0.402	1.68	3.37	0.139	1.96	0.128	0.018	0.095	16.38
N6	93L-2B 3.2 e	7.34	1.16	0.132	0.371	1.70	3.35	0.138	1.88	0.123	0.020	0.117	16.33
N6	93L-2B 4.1 c	7.36	1.11	0.130	0.388	1.64	3.44	0.126	1.90	0.115	0.015	0.059	16.28
N6	93L-2B 4.2 e	7.27	1.28	0.152	0.399	1.66	3.31	0.114	1.89	0.138	0.021	0.088	16.32
N6	93L-2B 5.1 c	7.40	1.09	0.118	0.379	1.64	3.41	0.105	1.93	0.116	0.016	0.106	16.31
N6	93L-2B 5.2 e	7.26	1.25	0.147	0.440	1.68	3.31	0.102	1.93	0.124	0.023	0.070	16.34
N6	93L-2B 6.1 e	6.98	1.54	0.207	0.547	1.77	3.15	0.120	1.92	0.163	0.018	0.159	16.58
N6	93L-2B 6.2 e also sm	7.43	1.05	0.124	0.390	1.61	3.41	0.121	1.94	0.109	0.016	0.076	16.27

Tuff of Cebolla Creek

Map Reference	Comment	Si	Al	Ti	Na	Fe	Mg	Mn	Ca	K	Cl	F	Total
CC	85L33C 69	6.90	1.71	0.242	0.546	1.56	3.27	0.077	1.87	0.178	0.018	0.161	16.54
CC	85L33C 70	6.91	1.68	0.249	0.558	1.51	3.30	0.081	1.91	0.181	0.014	0.172	16.56
CC	85L33C 71	6.91	1.69	0.255	0.557	1.57	3.25	0.091	1.87	0.161	0.016	0.157	16.52
CC	85L33C 72	6.54	2.12	0.327	0.637	1.72	2.93	0.085	1.93	0.203	0.010	0.155	16.66
CC	85L33C 74	6.45	2.32	0.330	0.680	1.63	2.92	0.052	1.92	0.205	0.010	0.175	16.69
CC	85L33C 74	6.39	2.38	0.329	0.657	1.58	2.99	0.043	1.93	0.209	0.010	0.138	16.66
CC	85L33C 75	6.55	2.18	0.352	0.682	1.67	2.84	0.076	1.91	0.180	0.011	0.140	16.59
CC	85L33C 76	6.91	1.64	0.248	0.543	1.56	3.34	0.079	1.89	0.163	0.017	0.178	16.57
CC	85L33C 77	6.93	1.64	0.256	0.538	1.57	3.27	0.079	1.90	0.184	0.018	0.187	16.56
CC	85L33C 103	6.97	1.60	0.242	0.542	1.55	3.29	0.084	1.90	0.169	0.019	0.182	16.55
CC	85L33C 104	6.98	1.63	0.243	0.571	1.49	3.29	0.080	1.89	0.155	0.018	0.134	16.48
CC	85L33C 105	6.68	1.97	0.283	0.609	1.63	3.12	0.077	1.90	0.200	0.014	0.160	16.64
CC	85L33C "35"	6.91	1.67	0.250	0.566	1.60	3.23	0.089	1.89	0.175	0.018	0.162	16.56

Tuff at MacDonough Reservoir

Map Reference	Comment	Si	Al	Ti	Na	Fe	Mg	Mn	Ca	K	Cl	F	Total
M	85L-36 1.1 c	7.02	1.53	0.188	0.434	1.92	3.04	0.089	1.93	0.195	0.030	0.086	16.46
M	85L-36 1.2 e	6.98	1.53	0.192	0.459	1.82	3.03	0.090	2.12	0.185	0.032	0.009	16.43
M	85L-36 2.1 c	6.61	2.02	0.289	0.615	1.76	2.99	0.083	1.93	0.212	0.020	0.041	16.57
M	85L-36 2.2 e	6.93	1.60	0.233	0.534	1.61	3.35	0.089	1.88	0.172	0.012	0.065	16.46
M	85L-36 3.1 c	6.82	1.81	0.248	0.520	1.79	2.93	0.084	1.99	0.204	0.026	0.011	16.43
M	85L-36 3.2 e	7.10	1.42	0.184	0.409	1.70	3.27	0.091	1.95	0.159	0.020	0.059	16.36
M	85L-36 4.1 c	7.09	1.50	0.190	0.456	1.76	3.08	0.077	1.95	0.182	0.034	0.047	16.37
M	85L-36 4.2 e	7.12	1.42	0.186	0.431	1.81	3.09	0.082	1.97	0.170	0.026	0.039	16.35
M	85L-36 5.1 sm	6.53	2.20	0.287	0.658	2.00	2.64	0.073	1.92	0.197	0.020	0.000	16.53