

Introduction and Description of Analytical Procedures

Introduction

The Aleutian volcanic arc, one of the longest active arcs in the world, is an important natural laboratory for studying processes of magma genesis and eruption. However, the Aleutian arc is remote and lacks extensive human habitation and its climate is harsh. As a result, less is known of its recent--that is, past 250 years--eruptive history (see summaries of historic eruptions by Coats, 1950, and Simkin and others, 1981) than of other volcanoes in more populated parts of the world. Consequently, the Holocene geologic record is essential for determining the frequency of explosive eruptions in the Aleutian arc. Airfall ash (tephra) deposits are an important part of that record because ash clouds typically accompany all but the most quiescent of eruptions. More importantly, tephra deposits preserve a stratigraphic succession that can be absolutely dated by the radiocarbon method where the tephra is interbedded with organic-bearing sediments.

We have sampled Holocene tephra deposits on the eastern Alaska Peninsula since 1982, during the course of mineral resource inventories, geologic mapping, and volcanologic studies. Additionally, samples have been received from other geologists and archeologists. In this report we present the analytical results and stratigraphic settings for all samples analyzed through 1998. Associated radiocarbon ages, correlations among samples, and implications of the correlations and ages to the frequency of Holocene eruptions in the eastern Aleutian arc will be reported elsewhere.

Methods

Samples from 50 sites are described here, from Mt. Veniaminof on the south to Augustine Volcano in Cook Inlet on the north ([see index map](#)). Many other sites were examined, but from a group of closely adjacent sites only those at which the greatest number of tephra deposits were preserved are reported. At most sites, only the thickest and (or) coarsest deposits were sampled because we did not have the resources to analyze every ash bed. Moreover, thin or fine-grained deposits are more prone to contamination by windblown silt than are thick deposits. Thus, our sampling method and results are biased in favor of the coarse-grained, voluminous deposits over fine-grained deposits of local extent. At some isolated sites or those that have only a few tephra deposits, however, we do report results on thin or fine-grained beds.

Samples were disaggregated by ultrasonic agitation in water, wet sieved, oven dried at 70° C, and examined by binocular microscope. In rare cases of persistent organic coating, samples were disaggregated by agitation in a mild solution of household bleach (sodium hypochlorite) and water for one to two minutes, then rinsed several times in tap water. The bleach removes organic coating but in dilute solution for short periods has no discernible effect on glass composition (Cormie and Nelson, 1983). Samples that were bleached during preparation are indicated by italics in the table of analytical results.

Glass separation followed initial cleaning. Vesicular glassy clasts--vitrophyre or pumice--presumably represent the juvenile material that was molten at the time of the eruption. Because of their low bulk density, these clasts are typically concentrated in the coarse size fractions. The juvenile clasts were subsampled by hand picking or by sieving a coarse size range; subsampling minimized contamination by fine sand- and silt-sized loess particles. The subsample was ground in an alumina-ceramic mortar and pestle and sieved to 0.10-0.06 mm, then washed to get rid of grinding dust. Glass crushes more readily than mineral grains and repeated cycles of sieving after a short interval of grinding were used in order to minimize loss of glass in the grinding dust. Glass was separated from mineral grains by immersing the crushed subsample in a mixture of acetone and methylene iodide having a density of about 2.58 g cm⁻³,

followed by treatment in an isodynamic magnetic separator. Mafic glass was especially difficult to separate from plagioclase microlites; these samples were typically subjected to a second cycle of density separation. Examination by polarizing microscope indicated 95 percent purity for most glass separates, although some mafic glass separates were only 80 to 90 percent glass.

After removal of the glass component, the mineral fraction was mounted on a slide for microscopic examination. Plagioclase is universally the dominant phenocryst phase in these andesitic and dacitic tephra samples and consequently is of little value in distinguishing among samples. The mafic phenocrysts clinopyroxene, orthopyroxene, and amphibole, however, vary sufficiently in their proportions to be potentially useful in distinguishing among deposits. Moreover, the densities of the mafic phases are approximately similar and except where one phase differs significantly in average grain size from the other two, proportions among the three should not change drastically by fractionation during transport. Grain mounts were point counted to determine the proportions of amphibole, clinopyroxene, and orthopyroxene. Trace phases such as apatite or olivine were also recorded.

Glass separates were analyzed by 9-channel electron microprobe (USGS, Menlo Park, Calif.) for nine major oxides: SiO₂, Al₂O₃, Fe expressed as FeO, MgO, CaO, Na₂O, K₂O, TiO₂, and MnO. Analysis was at 15 KeV and 0.01 microamperes beam current using a slightly defocused beam to minimize loss of Na and K from the glass. Each reported analysis is an average of multiple analyses, each of a different glass fragment. The set of individual analyses that composes each sample has been edited for (1) inadvertent inclusion of mineral microlites, recognized by simultaneous increase in the concentration of some elements (Na, Ca, and Al in the case of plagioclase) and decrease in others (Fe and Si in the case of plagioclase), or (2) widely disparate values of 3 or more of the elements. Where 2 or more of the disparate analyses are similar to one another, they are combined and reported separately as a minor glass component.

The analytical uncertainty--one standard deviation--of the seven major oxides (excluding Ti and Mn, for which 1 sigma can be more than 50 percent relative) is given for each glass component. Values are calculated for the background-corrected raw counts of the individual glass fragments, using the equation

$$(\sum (x_i - x_m)^2 / (n - 1))^{1/2}$$

where x_i is an individual count, x_m is the average of the set of counts, and n is the total number of counts in the set. The value is reported as a percent of the concentration because the absolute value has no intrinsic meaning.

Standards were a synthetic andesite glass ("GSC") for Na, Mg, Ca, K, and Fe, a natural rhyolitic glass ("ST2") for Si and Al, synthetic TiO₂, and synthetic Mn₂O₃. Analyses reported herein were obtained over a period of 13 years, using two different microprobes (SEMQ and JEOL). To compare results obtained on two different instruments, and to minimize time-dependant drift on each instrument, a natural rhyolitic glass was used as internal standard. Results of replicate analyses of RLS132 were as follows (one standard deviation is given in parentheses):

	Ave. of 3 analyses	Ave. of 18 analyses	Ave of 5 analyses	Ave. of 4 analyses	Ave. of 2 analyses	Wet chemistry
	<u>Until 1/86</u>	<u>1/86 - 4/87</u>	<u>12/89 - 2/91</u>	<u>1/94 - 1/98</u>	<u>3/98</u>	
SiO ₂	75.3(0.2%)	75.4(0.8%)	75.7(0.8%)	74.8	75.4	75.7
Al ₂ O ₃	11.3(1.2%)	11.3(1.4%)	11.6(2.7%)	11.7	11.6	11.4
Fe _T O ₃	2.34(0.2%)	2.33(1.9%)	2.31(1.3%)	2.40	2.29	2.33
MgO	0.04(12%)	0.06(18%)	0.06(9.8%)	0.05	0.05	0.05
CaO	0.11(2.3%)	0.11(9.1%)	0.11(12%)	0.10	0.09	0.12
Na ₂ O	4.74(1.3%)	4.88(2.7%)	4.90(1.7%)	4.92	5.14	5.25
K ₂ O	4.43(0.3%)	4.42(1.4%)	4.45(1.4%)	4.36	4.39	4.53
TiO ₂	0.19(5.4%)	0.19(5.3%)	0.19(8.2%)	0.20	0.20	0.21
MnO	0.13(3.1%)	0.16(6.2%)	0.15(3.8%)	0.12	0.14	0.15
Total	98.6	98.8	99.5	98.6	99.1	99.8

The only corrections that we have applied to the reported analytical results are that Na₂O in analyses acquired prior to 1/86 is increased by 3%, and Na₂O in the analyses of 3/98 is decreased by 5%, to 4.88 weight percent.

Analytical Results

A deposit sample is designated by a letter appended to the site number; numbers following the letter designate different glass components within a single sampled deposit (bed). Sample localities are arranged in the table in approximate order from south to north in the study area. All values in Table 2 were proofread at the time of entry.

Raw totals for the analyses range from about 92 to 100 percent. The shortfall is due in small part to gaseous species such as CO₂ or S that were not included in the analysis. The analysis deficit may also reflect accidental intersection of mounting epoxy adjacent to glass fragments or of unseen microvesicles within glass fragments by the analytical beam. Probably the greatest source of deficit, however, is hydration water in the glass. Low totals seem to be more common in fine-grained samples, probably because fine-grained ash is more prone to thorough hydration due to its high ratio of surface area to

volume. It may also be that fine-grained ash has a higher microvesicle content on average because highly pumiceous lapilli are readily comminuted to fine shards.

Acknowledgments

Professor D.E. Dumond, University of Oregon (emeritus), helped with sampling of tephra deposits near Katmai National Park headquarters and with attempts to identify the deposits described in Dumond (1979). For a more detailed description of these and other deposits from the vicinity of the Valley of Ten Thousand Smokes, see Riehle et al. (in press). Richard Waitt, U.S. Geological Survey, provided the samples from Augustine Island and from Shuyak Island. Tom Ager, U.S. Geological Survey, provided the stratigraphic section and samples from the Circle Lake sediment core near Homer. Richard VanderHoek, National Park Service, provided the samples and stratigraphic section at site 8. Lastly, the samples and stratigraphic columns at sites 34 and 38 are reproduced with permission from Karen Stilwell (1995; analyses done by C. Meyer). We appreciate the important additions to the database from these contributors.

Judy Hassen and Kathy Egger carefully sieved and described many of the samples. Tom Robbins (deceased), Bruce Rieke, Landis Lindgren, and George Taylor were the pilots of various charter helicopters during most of the sampling for this project; the skill of these and our other pilots in the face of demanding and suddenly changeable weather enabled us to collect as many samples as we did. To Captain Eric Stirrup of the M/V Ten Bears and Hank Pennington we owe thanks for getting us onto some remote beaches for sampling--and back.

The manuscript was carefully reviewed by Angela Roach, Alaska Volcano Observatory. This website was produced by Chris Nye and Frank Ganley from digital text and data files provided by the authors, a major undertaking due to the combination of size and complexity of the data and graphics.

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