APPENDIX D

VOLCANIC MATERIALS: SCIENCE LANGUAGE FOR THEIR NAMING AND CHARACTERIZATION IN DIGITAL GEOLOGIC-MAP DATABASES

Version 1.0

North American Geologic-map Data Model Steering Committee

Science Language Technical Team (SLTT)

Volcanic Subgroup

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[This report was formerly available at the North American Geologic Map Data Model Steering Committee website as http://nadm-geo.org/sltt/products/sltt_volcanic_12_18_04.doc.]

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1 EXECUTIVE SUMMARY

This document presents a classification of volcanic lithologies for use in digital geologic-map databases produced and distributed by public-sector geoscience agencies. The classification was developed by a multi-constituency panel of geoscientists representing the Geological Survey of Canada, the U.S. Geological Survey, State geological surveys, and the Bureau of Land Management.

The classification of volcanic lithologies and their attributes is part of a larger effort to develop a standardized data model for the storage, manipulation, analysis, management, and distribution of digital geologic-map information. This continent-wide effort is taking place under the auspices of a North American Geologic-map Data Model Steering Committee[1] composed of representatives from Canadian and American geoscience agencies. The data-model effort has several components:

(1) A standard conceptual model for storing digital data, and for manipulating these data in a relational and (or) object-oriented database environment;
(2) Standardized science language that allows geologic materials and geologic structures to be described, classified, and interpreted;
(3) Software tools for entering data into the standardized model at the front end (data-producer) and for extracting the data at the back end (data-user);
(4) Methodologies and techniques for exchanging data sets having different structures and formats.

This document addresses the science language of volcanic materials in terms of their composition, their texture, and their emplacement style.

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[1]Visit http://nadm-geo.org for information about the North American Geologic-map Data Model Steering Committee, and http://nadm-geo.org/sltt for information about the Steering Committee's Science Language Technical Team. See the Federal Geographic Data Committee (FGDC) website for the Subcommittee on Geologic Information at http://ncgmp.usgs.gov/fgdc_gds/datamodelprop.html. to learn about what the FGDC is doing about the science language of planar and linear geologic features.

2 INTRODUCTION

The Science Language Technical Team (SLTT) of the North American Data Model Steering Committee (NADMSC) is a multi-constituency group of geologic map producers and users that is developing prototype lists of descriptive lithologic terms for use in digital geologic map databases. The increasing use of digital geologic map databases highlights the need for standardized terminology to facilitate their widespread interchange and use.

The NADMSC was formed in 1999 as a partnership between the U.S. Geological Survey (USGS), the Association of American State Geologists (AASG), and the Geological Survey of Canada (GSC). This committee identified the need for standardized science language for use in North America and chartered the SLTT, first convened in early 2000.

2.1 Purpose

The purpose of this report is to develop standardized nomenclature for use in digital geologic map databases, specifically to describe lithologies in volcanic rock units. Although this nomenclature takes the form of a hierarchy of terms, it is important to note that this is not the same as a formal rock-naming system. Similarly, it is not a system for naming geologic map units and has nothing directly to do with stratigraphic nomenclature.

2.2 Intended Use

The intended use of this report is to provide standardized lists of attributes for use in databases that describe geologic maps.

2.3 Who developed this document, and how?

This document was developed by geoscientists from American and Canadian geoscience agencies (Table 2.3.1). The group was assembled in early 2000 as the Volcanic Science Language Technical Team (SLTT) of the North American Geologic-map Data Model Steering Committee. Members were appointed in the following ways:

(1) Most participants from the U.S. Geological Survey (USGS) were identified by Regional Geologic Executives from the USGS Western, Central, and Eastern Regions. Some USGS scientists were appointed by Coordinators of USGS line-item science programs;

(2) Scientists from the Geological Survey of Canada (GSC) were identified by Canadian members of the North American Geologic-map Data Model Steering Committee;

(3) Scientists from State geological surveys were identified by the Digital Geologic-Mapping Committee of the Association of American State Geologists (AASG);

(4) Scientists from the U.S. Bureau of Reclamation were selected by the overall chair of the NADMSC Science Language Technical Team.

Committee Members Volcanic Science Language Technical Team Steve D. Ludington and Robert L. Christiansen, co-Chairs	
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Frederic H. Wilson	U.S. Geological Survey

Table 2.3.1

The subgroup on volcanic rocks met face-to-face on May 1, 2001[2], to consider the best way to refer to the lithologies of volcanic rock units in a digital database for geologic maps. An initial schema was developed at that meeting, and subsequent refinements of the subgroup's recommendations have taken place among all the members by e-mail and telephone. Coordinators Steve Ludington and Bob Christiansen wrote this report.

2.4 Acknowledgments

The following persons provided comments, evaluations, and constructive criticism of various drafts of this report: Fred Fisher (U.S. Geological Survey, emeritus), J. Wright Horton, Jr. (U.S. Geological Survey), Richard Moore (U.S. Geological Survey), and Steve M. Richard (Arizona Geological Survey). We gratefully acknowledge their thoughtful feedback and contributions, even if we didn't always adopt their suggestions.

[2] Members attending: Steve Ludington, Bob Christiansen, Bruce Johnson, Reed Lewis, Richard Watson, Bill Steinkampf, Dave Wagner

3 BASIS OF SLTT VOLCANIC 1.0

3.1 Philosophical approach

The fundamental spatial characteristic of a geologic map is the map unit, which is defined and characterized at the discretion of the author of the map. Sometimes lithology is an important aspect of a unit definition, sometimes not. A geologic map unit may comprise only a single lithology, but more commonly it includes several different lithologies.

We consider it critical to remember that the purpose of our hierarchical subdivision of terms is to describe the *lithologic characteristics* of *geologic map units*. It is to be used to logically retrieve or select those map units that contain a specified set of lithologic characteristics. Thus, it must be flexible enough to accommodate the extremely varied and unsystematic way in which map units are described and defined by various authors. This report groups lithologic features necessary to adequately characterize **volcanic materials** in the map units of a geologic map database into three fundamental classes based on **composition, texture**, and **emplacement characteristics**.

No one of these classes is primary, and any or all may be used to select the lithologies of map units. The subdivision of any one of the fundamental classes consists of a list of words, arranged in a hierarchy that can be used to select lithologies. The words that describe these subdivisions are not given formal definitions here, but brief descriptions are given in the appendices. Many of the words have multiple, sometimes conflicting definitions and have been used differently over the years by different map authors. We have attempted to make the hierarchy sufficiently comprehensive, especially at the higher levels, to allow adequate lithologic characterization and to accommodate the vast majority of lithologic descriptions on existing geologic map legends.

For any descriptive parameter there may be many words that have been used to describe lithology. Some of them have been used widely, others only rarely. Some of them are commonly misused or are used inconsistently. We have attempted to place most of those words into a hierarchy that fulfills two important requirements:

(1) the hierarchy should not have ‘holes’, i.e., all commonly described lithologies should have a place in it;
(2) the parent-child relationships in the hierarchy can be generally agreed upon.

It is assumed that any particular map-unit lithology can be described in terms of any one, two, or all three of the first-level classes in the hierarchy of terms. Within any one of those classes, a lithology will be uniquely described by one control term, and any of those control terms will be defined by a unique logical path starting at the first level. Depending on the amount of information available, the path can end at any level. Thus, within one class, a particular lithology might be described by only a single very general term (*e.g.,* “volcanic rock”), or by a highly specific term at a different level in the hierarchy (*e.g.,* “shoshonite”). For any lithology, a complete geologic map database would include a term from each of the first-level classes (*e.g.*, rhyolite; obsidian; lava flow).

3.2 Special problems

Two special problems pertaining to volcanic lithologies in geologic map units require comment.

(1) Volcanic rock sequences commonly contain sedimentary materials. An example might be sandstone and conglomerate beds consisting largely or entirely of volcanic materials and intercalated with lava flows in a thick volcanic sequence. Such rocks

are commonly termed volcanic sedimentary rocks, but we do not provide a place for them in our hierarchy. They are described in the SLTT report on sedimentary terminology.

(2) A similar situation pertains to subvolcanic intrusive rocks. Most stratovolcanoes, for example, contain dikes and sills of intrusive rock similar in composition to the lavas and pyroclastic rocks that make up most of the edifice and are commonly intimately associated with the predominantly eruptive volcanic lithologies. They are to be described in the SLTT report on plutonic terminology.

4 ATTRIBUTION BASED ON COMPOSITION

Volcanic materials form a compositional continuum that makes any compositional classification arbitrary. There are numerous classification schemes in the literature for naming volcanic rocks. Probably the most important is that of Le Maitre and others (2002), which contains the formal recommendations of the IUGS Subcommission on the Systematics of Igneous Rocks. We have tried to construct a scheme that (1) includes most commonly used names, (2) is hierarchical, and (3) does no violence to other commonly used classification schemes. To the extent practical, we utilize the recommended compositional terms of Le Maitre and others, but we have included a few others that are in common use and fill descriptive needs. Note that we do not provide strict definitions of the boundaries between these classes based on either chemical or mineralogical criteria. Each method has its place, and both have been extensively used for existing geologic maps. For selection and retrieval of lithologies among the units of a geologic map database, the most important requirement is that the hierarchy be valid (Fig. 1).

Many phaneritic volcanic rocks are described using compositional terms based upon plutonic-rock nomenclature (perhaps with the prefix “micro-“ or with the additional appellation “porphyry”). For such materials, plutonic compositional nomenclature will probably suffice and is not further developed here. Other volcanic lithologies can be divided compositionally into **felsic volcanic material, mafic volcanic material, ultramafic volcanic material, high-alkali volcanic material, volcanic carbonatite**, and **lamprophyre**.

The felsic volcanic materials depicted in most geologic maps can be divided into **rhyolite, rhyodacite, dacite, trachydacite**, and **trachyte**.

Most mafic volcanic materials are divided into **andesite, basaltic andesite (basoandesite), basalt, trachyandesite,** and **trachybasalt**. A subtype of basoandesite is **icelandite**. Basalt subtypes may include **tholeiitic basalt, calc-alkali basalt**, and **alkali basalt**. Trachyandesite subtypes may include **benmoreite, latite, mugearite**, and **shoshonite**. Trachybasalt subtypes may include **hawaiite** and **absarokite**.

Ultramafic volcanic materials include **picrobasalt, picrite**, and **komatiite**.

High-alkali volcanic materials can be divided into **alkali rhyolite, alkali trachyte, phonolite, tephriphonolite, phonotephrite, tephrite, basanite**, and **foidite**. High-alkali rhyolite subtypes include **comenditic rhyolite** and **pantelleritic rhyolite,** and the high-alkali trachyte subtypes include **comenditic trachyte** and **pantelleritic trachyte**. Typical names for foidites are **nephelinite, leucitite**, and **melilitite**.

Two additional types of volcanic materials not included among the preceding groups are **volcanic carbonatite** and **lamprophyre**. Although varied mafic mineral assemblages are used to classify lamprophyre types, they are not reviewed or listed here.

Appropriate mineral-name modifiers can be appended to most of the names of volcanic materials on the above lists.

The hierarchy of terms for composition is shown schematically in the accompanying figure 1, and brief descriptions of the terms used are in appendix A.

5 ATTRIBUTION BASED ON TEXTURE

The highest-level textural division for volcanic lithologies (Fig. 2) is between **unconsolidated volcanic deposit** and **volcanic rock**. Unconsolidated volcanic deposits are subdivided with the following grain-size terms: **ash, lapilli-ash, lapilli, block-ash, blocks, bombs, scoria, pumice**.

Volcanic rocks are first divided into **fragmental volcanic rock** and **lava rock**. Fragmental volcanic rocks can be further subdivided using the terms **tuff, lapilli tuff, lapillistone, tuff breccia, pyroclastic breccia, agglomerate.**

A subtype of lava rock is **vitric lava rock,** which can then be further subdivided as **obsidian, vitrophyre, pitchstone,** or **perlite**.

The hierarchy of terms for texture is shown schematically in the accompanying figure 2, and brief descriptions of the terms used are in appendix B.

6 ATTRIBUTION BASED ON EMPLACEMENT CHARACTERISTICS

The most fundamental distinction in the mode of emplacement of volcanic (or predominantly volcanic) materials (Fig. 3) is among **intrusive volcanic rock, extrusive rock** (both of them formed more-or-less directly from erupted magma), and **volcaniclastic material**, composed of aggregated volcanic materials that were previously fragmented. Terms that characterize intrusive volcanic rocks would include terms like **volcanic dike, volcanic sill, volcanic laccolith, volcanic stock, volcanic plug, intrusive volcanic breccia**, etc. Most extrusive volcanic rocks can be described with the following subdivisions: **lava flow, lava dome, stratocone, shield**, etc. Lava flows can be further subdivided into **pahoehoe, aa, block lava, massive lava**, and **pillow lava**. Volcaniclastic materials can be further subdivided with the terms **pyroclastic material** and **volcanic epiclastic material**. Pyroclastic materials can be further described with the terms **pyroclastic flow, pyroclastic surge**, and **pyroclastic fall**. Pyroclastic fall can include **agglutinate (spatter), ejecta blanket, cinder cone, tuff cone**, and **tuff ring**.

The hierarchy of terms for emplacement characteristics is shown schematically in the accompanying figure 3, and brief descriptions of the terms used are in appendix C.

7 REFERENCES CITED

Le Maitre, R.W. (editor), Streckeisen, A., Zanettin, B., Le Bas, M.J., Bonin, B., Bateman, P., Bellieni, G., Dudek, A., Efremova, S., Keller, J., Lameyre, J., Sabine, P.A., Schmid, R., Sørensen, H., and Woolley, A.R., 2002, Igneous rocks: A classification and glossary of terms: Recommendations of the International Union of Geological Sciences Subcommission on the Systematics of Igneous Rocks: Cambridge, Cambridge University Press, 236 p.

8 APPENDIX A – TERMS BASED ON COMPOSITION[3]

Felsic (high-silica) volcanic material – volcanic material characterized by high SiO_2 or by a high relative abundance of feldspar, feldspathoids, and/or quartz.

Rhyolite – felsic volcanic material characterized by abundant modal or normative quartz and alkali feldspar and that generally contains more than about 69 weight percent SiO_2.

Rhyodacite – felsic volcanic material, sometimes distinguished from rhyolite or dacite, that generally contains from about 69 to about 73 weight percent SiO_2.

Dacite – felsic volcanic material characterized by some modal or normative quartz, alkali feldspar about equal to plagioclase, and that generally contains from 63 to about 69 weight percent SiO_2.

Trachydacite – felsic volcanic material, sometimes distinguished from trachyte or dacite, that has SiO_2 similar to trachyte but higher modal or normative quartz.

Trachyte – felsic volcanic material characterized by a low abundance of modal or normative quartz and that generally contains from about 60 to 69 percent SiO_2 and high Na_2O and K_2O.

Mafic (low-silica) volcanic material – volcanic material characterized by low SiO_2 or by a high relative abundance of Mg- and Fe-rich minerals and calcic plagioclase.

Andesite – mafic volcanic material of intermediate composition, generally with 57 to 62 weight percent SiO_2.

Basaltic andesite (basoandesite) – mafic volcanic material of composition intermediate between andesite and basalt, generally between 52 and 57 weight percent SiO_2.

Icelandite – basoandesite characterized by a relatively high ratio of iron to aluminum.

Basalt – mafic volcanic material that contains essential plagioclase and generally has SiO_2 between 45 and 52 weight percent; typical minerals include plagioclase of An content ≥ 50, pyroxene, and olivine.

Tholeiitic basalt – basalt of an iron-rich compositional series, generally characterized by disequilibrium between olivine and the groundmass.

Calc-alkali basalt – basalt that is neither particularly iron-rich nor nepheline-normative.

Alkali basalt – basalt of a low-iron compositional series characterized by olivine in equilibrium with groundmass, relatively high alkali metals, and normative nepheline.

[3] It should be noted clearly that this is not a formal classification or naming system for volcanic rocks but, rather, a listing of commonly used terms that fit within a hierarchical nomenclature for describing geologic map units. The descriptions here are intended only to be helpful but qualitative guides for understanding the hierarchy. For formal definitions, the IUGS report by Le Maitre and others (2002) should be consulted.

Trachyandesite – mafic volcanic material more alkali-rich than andesite and that generally contains from about 52 to about 60 weight percent SiO_2.

Benmoreite – trachyandesite that generally contains about 55 to about 60 weight percent SiO_2 and a relatively low ratio of K_2O to Na_2O.

Latite – trachyandesite that generally contains about 55 to about 60 weight percent SiO_2 and a relatively high ratio of K_2O to Na_2O.

Mugearite – trachyandesite that generally contains about 51 to about 55 weight percent SiO_2 and a relatively low ratio of K_2O to Na_2O.

Shoshonite – trachyandesite that generally contains about 51 to about 55 weight percent SiO_2 and a relatively high ratio of K_2O to Na_2O.

Trachybasalt – mafic volcanic material more alkali-rich than basalt and that generally contains from 45 to about 52 weight percent SiO_2.

Hawaiite – trachybasalt characterized by a relatively low ratio of K_2O to Na_2O.

Absarokite – trachybasalt characterized by a relatively high ratio of K_2O to Na_2O

Ultramafic volcanic material – volcanic material characterized by very low SiO_2 or by a very high relative abundance of Mg- and Fe-rich minerals, no or very little plagioclase, and no alkali feldspar or quartz.

Picrobasalt – ultramafic volcanic material intermediate between basalt and foidite containing 41 to 45 weight percent SiO_2 and less than 12 percent MgO.

Picrite – ultramafic volcanic material that is especially rich in olivine, containing less than 42 percent SiO_2 and 12 to 18 percent MgO.

Komatiite – ultramafic volcanic material containing more than 18 weight percent MgO and typically characterized by spinifex texture (a needle-like network of olivine grains that encloses intergranular pyroxenes).

High-alkali volcanic material – volcanic material characterized by a high percentage of Na_2O and K_2O or by essential alkali-rich pyroxenes or amphiboles.

Alkali rhyolite – rhyolite that contains alkali pyroxene or amphibole or a very high chemical abundance of Na_2O and K_2O.

Comenditic rhyolite – alkali rhyolite of peralkaline composition that has a relatively high ratio of aluminum to iron.

Pantelleritic rhyolite – alkali rhyolite of peralkaline composition that has a relatively low ratio of aluminum to iron.

Alkali trachyte – trachyte that contains alkali pyroxene or amphibole or a very high chemical abundance of Na_2O and K_2O.

Comenditic trachyte – alkali trachyte of peralkaline composition and that has a relatively low ratio of iron to aluminum.

Pantelleritic trachyte – alkali trachyte of peralkaline composition and that has a relatively high ratio of iron to aluminum.

Phonolite – high-alkali volcanic material that generally contains from about 55 to about 64 weight percent silica, has higher Na_2O and K_2O than trachyte, and contains feldspathoid minerals.

Tephriphonolite – high-alkali volcanic material that corresponds to high-SiO_2 trachyandesite, generally with about 50 to about 55 weight-percent SiO_2.

Phonotephrite – high-alkali volcanic material that corresponds to low-SiO_2 trachyandesite, generally with about 46 to about 50 weight-percent SiO_2.

Tephrite – high-alkali volcanic material that corresponds to basanite but is olivine-free.

Basanite – high-alkali volcanic material that is olivine-bearing and corresponds to basalt or trachybasalt but has higher Na_2O and K_2O and generally contains from 41 to about 49 weight percent SiO_2.

Foidite – high-alkali volcanic material characterized by the presence of significant amounts of feldspathoid minerals and the absence or very low abundance of feldspar.

Nephelinite – foidite in which the predominant feldspathoid mineral is nepheline.

Leucitite – foidite in which the predominant feldspathoid mineral is leucite.

Melilitite – foidite in which the predominant feldspathoid mineral is melilite.

Volcanic carbonatite – volcanic material composed primarily of carbonate minerals.

Lamprophyre – porphyritic volcanic material that contains abundant panidiomorphic phenocrysts of biotite, amphibole, and pyroxene and some feldspar or feldspathoid in a groundmass of the same minerals; K_2O is generally much more abundant than Na_2O.

9 APPENDIX B – TERMS BASED ON COMPOSITION

Unconsolidated volcanic deposit – volcanic material that is not lithified or indurated.

Ash – unconsolidated volcanic deposit and ejected from a volcano and characterized by grain size <2 mm.

Lapilli-ash – unconsolidated volcanic deposit ejected from a volcano and characterized by a mixture of ash and lapilli.

Lapilli – unconsolidated volcanic deposit ejected from a volcano and characterized by grain size between 2 and 64 mm.

Block-ash – unconsolidated volcanic deposit ejected from a volcano and characterized by a mixture of ash, lapilli, and blocks.

Blocks – unconsolidated volcanic deposit ejected from a volcano and characterized by angular fragments >64 mm.

Bombs – unconsolidated volcanic deposit ejected from a volcano and characterized by flight shaped fragments >64 mm.

Scoria (cinders) – unconsolidated volcanic deposit of highly vesiculated material having thick aphanitic or dull glassy vesicle walls.

Pumice – unconsolidated volcanic deposit of highly vesiculated material having thin glassy vesicle walls.

Volcanic rock – volcanic material that is lithified or indurated.

Fragmental volcanic rock – volcanic rock formed by lithification of an unconsolidated volcanic deposit.

Tuff – volcanic rock formed by lithification of ash.

Lapilli tuff – volcanic rock formed by lithification of lapilli-ash.

Lapillistone – volcanic rock formed by lithification of lapilli.

Tuff breccia – volcanic rock formed by lithification of block-ash.

Pyroclastic breccia – volcanic rock formed by lithification of blocks.

Agglomerate – volcanic rock formed by lithification of bombs.

Lava rock – volcanic rock that cooled directly from lava or magma and not as an aggregate of initially loose particles.

Vitric lava – lava rock composed primarily of glassy volcanic material.

Obsidian – vitric lava that is nonhydrated, is generally dark-colored, and has few or no phenocrysts.

Vitrophyre – vitric lava that has conspicuous phenocrysts in a matrix of glass.

Pitchstone – vitric lava characterized by hydrated glass with a dull luster.

Perlite – vitric lava characterized by hydrated glass with a distinctive spherical fracture texture.

10 APPENDIX C – TERMS BASED ON EMPLACEMENT CHARACTERISTICS

Intrusive volcanic rock – volcanic material emplaced beneath the ground surface.

Volcanic dike – a tabular body of intrusive volcanic rock emplaced into a fracture, typically across preexisting volcanic materials.

Volcanic sill – a tabular body of intrusive volcanic rock emplaced between preexisting volcanic strata.

Volcanic laccolith – a body of intrusive volcanic rock emplaced between preexisting volcanic strata and that has bulged the overlying strata upward.

Volcanic stock – an equant body of intrusive volcanic rock.

Volcanic plug – a body of intrusive volcanic rock emplaced into the upper part of an eruptive volcanic conduit.

Intrusive volcanic breccia – a body of intrusive volcanic rock emplaced as fragmental material, typically not sorted.

Extrusive rock – volcanic material erupted as lava and emplaced on the ground surface.

Lava flow – extrusive rock resulting from outpouring of lava and having a tongue-like or sheet-like form.

Pahoehoe – lava flow having a continuous, commonly folded or ropy vesicular crust.

Aa – lava flow having a carapace of rough spiny-textured blocks.

Block lava – lava flow having a carapace of relatively smooth broken blocks.

Massive lava – lava flow having no conspicuous crust or carapace.

Pillow lava – lava flow having prominent bulbous, flattened, or elongate sack-like forms resulting from subaqueous emplacement.

Lava dome – extrusive rock resulting from outpouring of lava and having a bulbous form.

Stratocone – a volcanic edifice consisting largely of layered extrusive rocks, both lava flows and pyroclastic materials, erupted from one or more central vents and displaying steeply sloping flanks.

Shield volcano – a volcanic edifice consisting largely of lava flows erupted from one or more vents and typically displaying gently sloping flanks.

Volcaniclastic material – volcanic material that was fragmented before deposition of the unit in which it is found, including clastic volcanic materials formed by various processes of fragmentation, transporting agents, and depositional environments, and possibly mixed with subordinate nonvolcanic fragments.

Pyroclastic material – an aggregate of volcaniclastic material deposited directly after ejection from a volcanic vent.

Pyroclastic flow – pyroclastic material emplaced by lateral flowage of an essentially unsorted mixture of hot gases and pyroclastic ejecta.

Pyroclastic surge – pyroclastic material sorted and emplaced by impulsive density currents of hot gases and pyroclastic ejecta.

Pyroclastic fall – pyroclastic material ejected, sorted in the air, and deposited in beds.

Agglutinate – pyroclastic fall forming a coherent deposit solidified from originally plastic ejecta.

Ejecta blanket – pyroclastic fall that covers a broad area and does not exhibit a distinctive morphologic form.

Cinder cone – pyroclastic fall of loose vesicular fragments and forming a conical volcanic edifice.

Tuff cone – pyroclastic fall of coherent pyroclastic material that was water saturated during emplacement and forming an edifice with a high rim and steeply sloping flanks.

Tuff ring – pyroclastic fall of coherent pyroclastic material that was water saturated during emplacement and forming an edifice with a low rim and gently sloping flanks.

Volcanic epiclastic material – an aggregate of volcaniclastic material that was re-deposited by sedimentary processes.

Volcanic avalanche – volcanic epiclastic material, possibly mixed with other material, emplaced by gravitational collapse from a volcanic edifice and subsequent rapid flowage.

Volcanic debris flow – volcanic epiclastic material consisting of initially water-saturated rock debris that flowed rapidly under the force of gravity; this term includes most deposits designated by authors as lahars.

11 APPENDIX D – PICKLISTS OF VOLCANIC TERMS

The accompanying file “SLTT_volcanic_picklists_12_18_04.xls” provides picklists of volcanogenic terminology developed from Figures 1, 2, and 3.