# Appendix II

# Checklist for Tephra Analysis

## Sample Processing

* drying temperature
* filtering or sieving material (e.g., copper, plastic)
* chemical treatments
* density separation fluids used
* ultra sound treatment
* magnetic separation

## Physical Characteristics

* mean particle size using terminology modified from Fisher, 1961, Schmid, 1981, and Chough and Sohn, 1990 (Table 1).

Given that strategies for size analysis are often based on different assumptions (mostly shape), when multiple size-analysis techniques are required because of a wide size range, e.g. mechanical sieving and laser diffraction, a few size categories should be analyzed with all strategies in order to better combine the results (e.g. Eychenne et al. 2012, Bonadonna et al. 2015).

* petrography - report assemblage and relative abundance of crystal phases
* alteration/hydration - of clasts and shards, surface or pervasive, etc.
* color of juvenile components (using a Munsel rock color chart)
* glass color (clear, brown, black, etc.)
* grain morphology - use guides and SEM analysis (see Cioni et al.,2008). Surface features, 3D shape.
* groundmass crystal content (it is even useful to know if the groundmass glass is microlite poor or microlite rich)
* vesicularity of juvenile clasts (approx. percent vesicles)
* shard density by analysis of vesicularity

### Lapilli Deposits (>8 mm) only (in addition to the above)

* componentry (for coarse deposits). If needed, component analysis should be done at least up to 1 mm diameter. Always report the percent of sample analyzed.
* Internal clast fabric (e.g., tube pumice vs spherical vesicles)
* vesicularity of juvenile clasts (approx. percent vesicles)
* Juvenile clast density by immersion.
* clast shape analysis

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## Geochemistry

* indicate type of geochemical analysis
* indicate type of material analyzed (glass, Fe-Ti oxides, crystal phase, specific juvenile component etc.)

### Scanning Electron Microscopy/EDS

* we have no guidance listed here

### Major Element Analyses

#### Electron probe microanalysis (EPMA)

* review recommendations in Kuehn et al. (2011)
* disclose type of instrument and location of facility
* disclose analytical conditions including beam diameter, accelerating voltage, beam current, count times for each element
* report any automation software and any correction routines (e.g. CIT-ZAF reduction of Armstrong, 1995)
* report calibration standards (primary standards) and which elements they were used to calibrate as well as and working standards (secondary standards)
* report methods used to monitor instrument drift during sample analyses (i.e. routine analysis of secondary standards and methods of correcting drift)
* report methods and software (including version) used to reduce Na2O diffusion
* analyze and report concentrations for SiO2, TiO2, Al2O3, FeOT, MnO, MgO, CaO, Na2O, K2O, Cl, P2O5, S
* Report analytical total (not just an average)
* report number of point analyses per sample - 20 or more points on homogeneous glass is recommended with totals > 95%, more for heterogeneous glass
* filter data to remove crystal phase analyses, points contaminated by microlite inclusions and multiple populations of glass; for heterogeneous glass report all data so show range
* report normalized, average data with standard deviations within the report
* report raw, unnormalized, point data as supplementary material
* report raw, unnormalized, point data on working standard results as supplementary material

### Whole rock (XRF) bulk analysis (used in proximal settings—not for long-distance correlations)

* disclose type of instrument and location of facility
* number of clasts analyzed
* disclose instrument conditions or reference existing standard methods (e.g. Johnson et al. 1999)

### Trace Element Analyses

#### Laser-ablation ICPMS- Minor and Trace elements

* disclose type of instrument and location of facility
* disclose instrument conditions including beam parameters
* report standards used to calibrate the instrument and internal standards used to monitor instrument drift.
* disclose calibration routine
* report any automation software and any correction routines
* report number of points analysed per sample

#### Ion Probe Microanalysis (secondary ionization mass spectrometry) - Minor and Trace elements

* disclose type of instrument and location of facility
* disclose instrument conditions including beam diameter
* report standards used to calibrate the instrument and internal standards used to monitor instrument drift.
* disclose calibration routine and how values for internal standards (e.g., how Ca, Si ) were measured. Usually mapped with EMPA or SEM/EDS
* report any automation software (including version) and any correction routines
* report number of points analyzed per sample
* report method used for sample preparation and background material used (epoxy, carbon plates, glue)

### ICP-MS on pure glass splits or juvenile lapilli (bulk analysis)

* disclose type of instrument and location of facility
* disclose instrument conditions or reference existing standard methods (e.g. Pearce et al. 2007; Pearce et al. 2010)
* Sample acidification protocols (HNO3, HF, how clean and duration

## References

Armstrong, J.T., 1995, CITZAF—A package of correction programs for the quantitative electron microbeam x-ray analysis of thick polished materials, thin films, and particles: Microbeam Analysis, v. 4, p. 177–200.

Bonadonna, C., Cioni, R., Pistolesi, M., Elissondo, M., & Baumann, V. (2015). Sedimentation of long-lasting wind-affected volcanic plumes: the example of the 2011 rhyolitic Cordón Caulle eruption, Chile. Bulletin of Volcanology, 77(2), 13.

Cioni, R., D'Oriano, C., & Bertagnini, A. (2008). Fingerprinting ash deposits of small scale eruptions by their physical and textural features. Journal of Volcanology and Geothermal Research, 177(1), 277-287.

Eychenne, J., Le Pennec, J. L., Troncoso, L., Gouhier, M., & Nedelec, J. M. (2012). Causes and consequences of bimodal grain-size distribution of tephra fall deposited during the August 2006 Tungurahua eruption (Ecuador). Bulletin of Volcanology, 74(1), 187-205.

Johnson, D.M., Hooper, P.R., and Conrey, R.M., 1999, XRF analysis of rocks and minerals for major and trace elements on a single low dilution Li-tetraborate fused bead: Advances in X-ray Analysis, v. 41, p. 843–867.

Kuehn, S. C., Froese, D. G., & Shane, P. A. R. ,2011, The INTAV intercomparison of electron-beam microanalysis of glass by tephrochronology laboratories: results and recommendations. Quaternary International, v. 246, n.1, 19-47.

Pearce, N.J.G., Denton, J.S., Perkins, W.T., Westgate, J.A., Alloway, B.V., 2007. Correlation and characterisation of individual glass shards from tephra deposits using trace element laser ablation ICP-MS analyses: current status and future potential. Journal of Quaternary Science 22, 721e736.

Pearce, N.J.G., Perkins, W.T., Westgate, J.A., Wade, S.C., 2010. Trace-element microanalysis by LA-ICP-MS: the quest for comprehensive chemical characterization of single, sub-10 mm volcanic glass shards. In: Abstracts, International Field Conference on Tephrochronology, Volcanism, and Human Activity, Kirishima, Japan (9e17 May). INQUA International Focus Group on Tephrochronology and

Volcanism (INTAV), pp. 77e78.

## Geochronology

* report the method of dating (radiocarbon, mineral phase, fission track, correlation, modeled, magnetostratigraphy, etc.)
* report laboratory facility used for dating and their lab sample ID
* description of material dated
* reported age
* standard error on age

### Radiocarbon dating

|  |  |  |
| --- | --- | --- |
| **Suitable Materials** | **AMS** | **Conventional** |
| Woody | 2-5 mg | 10-25 g |
| Macrofossils (leaves, seeds, twigs, roots, pollen, and phytoliths) | 2-5 mg | 10-25 g |
| Charcoal (as long as it’s not detrital) | 1-5 mg | 10-100 g |
| Peat | 2-20 mg | 20-200 g |
| Humic soils and paleosols (soil organic matter) | 10-200 mg | 100-2,000 g |

AMS-accelerator mass spectrometry technique; Conventional- counting technique; numbers are sample sizes for the given techniques.

* raw age for 14C ages
* calibrated age, and method used to calibrate

### Radiometric dating

* + xxx

### Fission-track dating of glass

* + xxx

### Magnetostratigraphy

* xxx

### Depositional age modeling

* Time scale method (e.g. annual layer counting for ice cores
* Area interpolation (time between two maker horizons)
* Other

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