

Dear Editor,

We would like to thank you and the reviewers for evaluating our manuscript. We appreciate the constructive comments and suggestions provided to improve our work.

In response, we have carefully revised the manuscript and prepared a detailed, point-by-point reply addressing each of the reviewers' comments, which is attached to this submission.

As requested by both reviewers, we extensively re-evaluated the geochemical datasets, including a thorough inspection of both processed and unprocessed data. During this review, we excluded SEM-EDS, EPMA-WDS, and LA-ICP-MS data originating from less precise analytical sessions or individual data points potentially affected by microcrysts. As a result, the number of tephra samples with available geochemical data was slightly reduced as for one sample its major-element composition and for five samples their trace-element compositions were rejected. For other samples only single data points were rejected, if their quality was questionable. These changes did not affect the overall conclusions of the manuscript.

The revised datasets are provided as "temporary" files within the supplementary material for evaluation of the revised version. The corresponding individual data files (for each respective sample) are currently being updated within the database TephraAta. The supplementary files will also be used to update the data stored at the second repository, EarthChem (which we again have listed within the Assets section). The EarthChem dataset will remain under embargo during the review process to allow continued access for evaluation and potential modification. The embargo will be lifted upon acceptance of the manuscript. Once publicly available via EarthChem, the attached "temporary" supplementary dataset files will not be needed as part of the publication.

In addition, we implemented several improvements suggested by reviewer II to the database structure, including adjustments to the naming and subdivision of categories, enhancements to filter functions, and the addition of documentation files describing the input categories. These documentation files are also included in the supplementary material and may be suitable for publication.

All of these modifications have been incorporated into the revised manuscript, together with the additional changes requested by the reviewers.

We hope that the revisions satisfactorily address all comments and improve the clarity and quality of the manuscript. We thank you again for your consideration.

Kind regards,

Niklas Leicher

Comments on “TephAta - An online data collection of tephra data from the Atacama Desert” by  
**N. Leicher and co-authors submitted to ESSD**

This manuscript introduces a large database of tephras from the Atacama Desert, northern Andes. The database comprises comprehensive information of the occurrence, high quality major, minor and trace element glass composition, and compilation of age determinations of about 100 individual tephra samples covering the age interval from Quaternary to Miocene. The majority of the data including Ar-Ar dating results were obtained by the authors; some literature data have been also included. The database is available in web and also as Excel files making it very convenient to use on-line or on local computer. The structure of the database is aligned with recommendations from the tephra community and thus is compatible with other databases (e.g. EarthCHEM). I want to specially emphasize that all the data is accompanied by comprehensive information on reference materials analyzed during the same analytical sessions. This is excellent example of how geochemical tephra data should be reported in any publication. The manuscript provides quite detailed analysis of the age data, compositional variations of tephras, their clustering, and possible implications for the ongoing and future research. The manuscript is very well written and without doubts is a major contribution to the tephrochronology of Andes with many important applications.

My major recommendation to authors is to try clean the database as thoroughly as possible already on this stage (when it is not too large), exclude all data of questionable quality or not supported by data on reference materials, exclude data with totals less than 90-92% and more than 101.5%, exclude obvious compositional outliers, check the correctness of web output (I specify the questions below).

Overall, I strongly recommend publication of this contribution after minor revisions, suggestions for which are placed below and mainly concern geochemical methods and results.

Thank you for reviewing our manuscript and acknowledging our work. We appreciate your comments and thoroughly reviewed the data within the database. A point-by-point reply is found below, listing our statement and adjustments made in the manuscript (in italics, blue colored).

Line 65: Perhaps magma-crust interaction is particularly important in Andes, but in general it is not prerequisite for eruption- or volcano-specific fingerprint. Common factors resulting in volcanic glass variability is different extent of crystallization and variations in parental magma compositions.

We rephrased the sentence to provide a more general explanation for the evolution of volcano-specific fingerprints.

*Geochemical variations specific to individual volcanoes and eruptions are driven not only by parental magma composition and the degree of crystallization, but also by the geodynamic evolution of the Andes. The spatial and temporal differences in the thickness and composition of the crust, led to varying degrees of magma-crust interactions and thus to variable/additional magmatic differentiation of individual eruptions (Kay et al., 2010; Brandmeier and Wörner, 2016; Burns and De Silva, 2023).*

Line 71: Are sedimentation rates high enough in the Atacama Desert to provide high temporal resolution of the archives?

We adjusted the sentence and incorporated a statement on the temporal resolutions of archives. We further clarified our originally addressed statement, that the “dry” environmental conditions of the Atacama Desert with low physical and chemical weathering ensured a good preservation of tephra layers in sedimentary archives, being less affected by alteration as tephra in other, more humid environments. We have further incorporated information about sedimentation rates

*The Atacama Deserts' long-term aridity, is thought to have initiated as early as ca. 25 Ma ago (Dunai et al., 2005; Evenstar et al., 2017) and sets with the low degree of erosion and weathering (e.g., Ritter et al., 2023) suitable climatic conditions for the preservation of volcanic deposits. Despite dominating easterly wind systems, tephra deposits can be found abundantly from the Andes to the Pacific coast (Marquardt et al., 2005; Vásquez and Sepúlveda, 2013; e.g., Breitzkreuz et al., 2014). Tephra layers serve as crucial isochronous markers for dating sedimentary sequences within this arid environment, where other dateable materials are scarce and the temporal resolution often sediment records is often low.*

Line 82: Whole-rock analysis is also technically more complicated, time-consuming and expensive compared to glass analysis by microanalytical techniques

We agree that whole-rock analyses can be more complicated, time-consuming and expensive compared to glass analysis by microanalytical techniques. We adjusted the paragraph to make clear that we rather addressed the general comparability of data (single component vs. bulk analyses), which affects tephra correlations (for changes see also comment on line 83 below).

Line 83: not only lateral variations; crystal/glass in tephra layers are often vertically/temporally variable.

We included this in the adjustment of the paragraph.

*Comprehensive results of this research including geochemical (whole-rock compositions and isotopes) and chronological data are made available within the Central Andes Geochemical and Geochronology database (<https://andes.gzg.geo.uni-goettingen.de/>). Whole-rock analyses, however, have been found to be less suitable for tephrochronological alignments due to site-dependent variations in their main components (variable relative abundances of glass, crystals and lithics) caused by aeolian fractionation, temporal eruptive variations and the influence of alteration (Tomlinson et al., 2012a; Lowe et al., 2017).*

Line 165 and the above description of the database and web interface:

This is great web tool! I really like it. However, the authors may want to check the data and web output more thoroughly. For example, for randomly selected sample #TSdU, the output table contains wrong original totals (117% etc.). Supplementary table is correct.

We reviewed all data stored within TephAta to ensure data quality. We revisited original data to exclude data of sessions with reduced analytical uncertainty and further inspected major, minor and trace element glass data for the influence of potential mineral phases or malfunction of individual analysis. We apologize for copy/edit mistakes in the previous version (such as wrong totals), which now have been corrected. All geochemical data is removed from the database, and the revisited datasets are currently being reuploaded. A compilation of all reviewed data will be made available within a revised version as supplementary material.

Apparently, the 100%-normalized data in the web tables and supplementary table to this manuscript does not account for the substitution of halogens for oxygen, though it is said in the heading line of the supplementary table. Minor thing but better do it or explain clearly that Cl, F and S were not included in normalization and this is deviation from the recommended by Wallace et al. 2022 procedure.

Our EPMA-WDS data (totals) does account for the substitution of halogens (Cl, F) for oxygen during data reduction by the JEOL software. We apologize for a formatting issue, which presented a excel-calculated sum and not the halogen corrected value. We have replaced the affected data with the corrected values. We did not include volatiles (Cl, F, SO<sub>3</sub>) in the normalization for 100% water-free compositions, as recommended in Lowe et al., 2011 and commonly applied within the community. We did not find such

recommendations (including volatiles in water-free normalization) in Wallace et al. (2022). We rephrased the methods section and included information about our data reduction.

*Data reduction included ZAF correction and substitution of halogens (Cl, F) for oxygen using the JEOL Ltd JXA8900 Basic Software V3.02. Only EPMA-WDS geochemical analyses of glass fragments with analytical totals >90 wt. % were considered and normalized to 100% on a loss on ignition free basis, excluding volatiles (Cl, SO<sub>3</sub> and F).*

Presumably, the authors did quality checks before entering this data into database. Or not? Was there any screen based on the values of original total? Do authors believe that totals as low as 90% and less are real, that is, due to glass hydration? One of the samples in Supplement has original total of 58% - check it.

We apologize for erroneous data with totals <90%, which accidentally was copied to the supplementary data. We removed such data from the database and data stored at EarthChem/Supplement. Our quality cutoff value has been chosen at 90% to account for high magmatic water contents, any post-depositional hydrations and/or alteration, not measured elements and analytical uncertainties. We agree that 90% is at the lower end of values being heterogeneously discussed within the community (cf. Lowe, 2011), but suggest to keep this value, so that people reusing the data can apply own quality criteria, if higher values are preferred as also applied within other databases (Portnyagin et al., 2020). We have also added information about the 90% cutoff-value to the methods section, to make it aware during reuse of the data (see comment above). We also flagged data with low totals (>90-<92 wt.%) within the datasheets (comment in column H: data\_point\_notes).

Line 277: Please, clarify that grain-specific SiO<sub>2</sub> was applied only to samples with heterogeneous composition (as explained below). What was criteria of “heterogeneous composition”? SiO<sub>2</sub> range?

After a comprehensive review of the entire dataset, we re-examined the two samples for which LA-ICP-MS data reduction had been based on grain-specific SiO<sub>2</sub> values. We recognize that our previous description of this approach was unclear and, in part, inaccurate, and we sincerely apologize for this oversight. The grain-specific SiO<sub>2</sub> data in question were obtained during SEM-EDS sessions for which no secondary standard measurements are available. Although these values showed good agreement with the corresponding EPMA-WDS data of the sample, the lack of secondary standard data limits their analytical robustness. Consequently, we excluded these grain-specific SEM-EDS data and instead applied the median SiO<sub>2</sub> concentrations determined by EPMA-WDS consistently across all samples in the dataset as also SiO<sub>2</sub> concentrations appeared homogenous. The methods descriptions within the manuscript have been corrected. (see also comment below)

Line 296: Was Ca by LA-ICP-MS compared with Ca from EMPA data to monitor potential contamination by mineral phases? In general, how precisely was Ca content reproduced by LA-ICP-MS? This is unfortunate that some more major/minor elements were not analyzed (Ti, Na, P etc.); this precludes rigorous analysis of the data quality and screening out of contaminated data.

After having a quick look at the data, I suggest that some variations of trace elements can be compromised by contamination during laser ablation. As an example, let us look at the composition #TIB4-TEPH1. Major elements are relatively homogeneous with SiO<sub>2</sub> range of 76.5-78% with only one obvious outlier having Na<sub>2</sub>O=1.5%. Trace elements were calculated using sample-averaged SiO<sub>2</sub>. The trace element and also Ca concentrations are quite variable (~2x variations, 2 points have very contrasting compositions). How the authors can prove that these variations reflect heterogeneous glass composition and do not result from contamination by mineral phases during laser ablation? Another example, analysis #52.4-PAG17.2/008-12 with high Ca and Sr, which is very likely contaminated by plagioclase during analysis.

I should mention that this is a common problem of all studies which do not analyze major elements by

LA-ICP-MS. Perhaps, the authors can write a kind of disclaimer that some contaminated data may be present in the database and should be used with caution.

We added information about data reduction of LA-ICP-MS data to the method section, explaining how crystal-contaminated data was detected. The median accuracy of Ca measurements of LA-ICP-MS measurements at the UoC was at about 8.5% and at the UoB at 4.1 %. We also stated that no other major elements were measured for considering the influence of crystal-contamination, so that during re-use of the data, people are aware of potential contamination being undetected. However, we revisited all LA-ICP-MS data to screen for glass compositions, which may have been influenced by minerals within ablation and their overseen in the first data compilation. Such data, as the one from the given example (PAG17.2/008) were excluded from that data (e.g. like the given examples) to minimize the bias.

*As an internal standard  $^{29}\text{Si}$  was incorporated using median  $\text{SiO}_2$  concentrations obtained from EPMA-WDS data of respective samples. Since major and minor elements such as Ti, Na, K, or P were not analyzed by LA-ICP-MS, they could not be considered for detection of potential contamination by mineral phases during ablation. However, during data reduction in Iolite, the full analyzed trace element spectrum and Ca were screened to identify and exclude potential mineral inclusions (e.g. relatively elevated Ca, Sr, or Ba counts indicating feldspar inclusions) from data selection.*

Line 309: One standard deviation or two? Two SD (or RSD) should be reported that corresponds to ~95% probability.

We had calculated the relative standard deviation using a one standard deviation. We have now changed this according to the suggestion of both reviewers using a relative two standard deviation (two standard deviation/mean).

Line 340: “Crypto” refers to invisible tephra layers, disseminated in host sediments/ice.

We agree on that definition and have adjusted the sentence to clarify the meaning.

*The typical thickness of tephra layers is in the scale of centimeters, but also include several m-thick to sub-cm thin and tephra deposits, whose lateral extent ranges from decimeter to hectometer. In addition, cryptotephra horizons have been identified in sediment cores.*

Line 428: This is unclear why the legacy data for sample #2-3-5-2, which are not supported by standard measurements, are included in the database. I suggest to delete all questionable data from the database. This will increase the database value, consistency and reliability.

We included the legacy data to have a most complete dataset that also accounts for existing data but had flagged this data as not reliable within the download file of the EPMA-WDS data. This should also serve as an example that the database is suitable for storing legacy geochemical data. However, we see the point that flagging of the data might be overseen and thus removed these entries.

Line 453: As most of the samples are rhyolites, many trace elements behave as rather compatible elements due to strong partitioning into major and accessory mineral phases: Zr-Hf, U in zircon, Sr in plagioclase, Rb, Nb, Cs, Ba in biotite, Ba, Sr in sanidine, LREE in apatite and allanite, HREE in garnet and amphibole. Thus, the argument for using trace elements should be reformulated.

We revised the argument and included further arguments why trace element compositions can be more diagnostic to distinguish between rhyolitic compositions compared to major and minor element compositions.

*Due to their generally more incompatible behavior and lower concentrations of trace elements compared*

*to major and minor elements within the melt, trace elements effectively amplify compositional variations driven by differences in the parental magma source and magmatic history (e.g. fractional crystallization, degree and depth of melting, or residual mineral assemblages). Thus, trace element geochemistry of glass shards have been shown to be a reliable parameter for distinguishing between eruptions with similar major element composition (Tomlinson et al., 2012; Pearce, 2014; Hopkins et al., 2021).*

Figure 4. Lead should be placed between Ce and Pr on spider-diagrams if the elements are ordered according to their incompatibility in basaltic systems. Then, the subduction-related Pb enrichment will be seen better.

We changed the order as requested.

In plots 4 (f-i), what is shown by black symbols placed between 1 and 2?

We adjusted Figure 4 according to the revisited dataset and clarified the assignment of compositional groups in the figure.

Line 501: It is clear from the above that CG1, CG2 and CG9 are not “layers” but “groups of tephra of similar composition”.

We rephrased this paragraph to make clear that tephra layers of compositional groups are addressed.

*Some tephra layers were found in different sedimentary archives (e.g., tephra layers of CG1, CG2, CG9).*

Line 540: Perhaps I missed some text but would it be possible to identify volcanic sources of some tephra and give this information in separate chapter?

We avoided an in-depth discussion about potential volcanic sources at the present state, as the lack of suitable data (glass geochemical data, precise chronological data of young eruptions) from proximal volcanic deposits does not enable a robust correlation at present and is beyond the scope of the current paper, presenting the database. We planned to investigate the source of the identified eruptions within future work, including more proximal data and refined chronological information to ensure robust alignments.

## MEMORANDUM

**To:** Copernicus Editorial Support Team

**From:** Kristi Wallace

**Subject: Review comments for manuscript:** “TephAta – An online data collection of tephra data from the Atacama Desert” by Niklas Leicher et al.

Dear Editors,

Thank you for the opportunity to review this important manuscript. Below are my comments on the subject paper. I have used the review tools in Adobe Acrobat to add comments directly on the PDF (essd-2025-422\_KW) and have also summarized them in bullet form below.

This manuscript describes an important regional tephra database for the Atacama Desert and Northern Andes, including detailed metadata on field sites, samples, chronology, stratigraphy, and glass geochemistry (major, minor, trace elements, and some isotopes) for 106 mid-Pleistocene tephras. I commend the authors for adopting best practices established by the global tephra community (Wallace et al., 2022) in building the TephAta database. Specifically, the authors have documented and reported key metadata (using predefined lists even), provided raw point geochemical data rather than averages, and included both primary and secondary analytical standards along with detailed methods.

This dataset represents a significant contribution to the literature and the scientific community. It will enable a wide range of applications across multiple disciplines, including volcanology (e.g., eruption histories, ash impacts, hazard assessment), archaeology (e.g., impacts, chronology), climate studies, and more. TephAta is the first accessible tephra database for this region and sets an excellent precedent for making tephra data FAIR, while encouraging future growth through contributions of new data and well-vetted legacy datasets. Furthermore, the authors have registered all stations (field sites) and samples with IGSNs, further adhering to FAIR data standards. The incorporation of tephra community best practices into the database design also establishes a strong model for future users and data collectors. Finally, the database includes a user-friendly front end, which will broaden accessibility and facilitate contributions over time.

## GENERAL COMMENTS

Overall, the content of the manuscript is excellent. However, I recommend a thorough copy edit to improve clarity and readability in English especially in the abstract and introduction sections (subsequent sections are in better shape). While reviewing, I found numerous sentences that could benefit from rephrasing for clarity. Addressing all of these would require considerable time, so after a few pages, I shifted my focus from detailed copy edits to broader comments and technical issues. My review therefore emphasizes the manuscript's content, overall impact, and the value of the TephAta database it introduces, rather than line-by-line language corrections.

I appreciate the front-end user interface and the ability to plot data on maps and in geochemical space. Great job incorporating these tools, they not only enhance usability but also make it easier for me to evaluate the data within the database.

Thank you for acknowledging our work and providing valuable comments for further improvement of the manuscript. We followed your suggestions and appreciate your efforts in improving clarity and readability of the text. A point-by-point reply is found below, listing our statement and adjustments made in the manuscript (in italics, blue colored).

I am not a petrologist/geochemist and therefore unable to add substantive comments on trace element geochemistry and groupings (lines 452-495)

**Line 26:** please include physical and chemical characterization of tephra layers (location, geochem, age, physical characteristic) and not just geochem and age especially since the term 'tephrostratigraphic framework' is included in the sentence.

We rephrased the sentence:

*To develop tephrostratigraphic frameworks, precise physical, geochemical and chronological characterization of tephra layers and their sampling site is needed.*

**Line 30:** not sure "volcanic glass" is needed in parenthesis here as the stratigraphy is documenting the tephra layer itself which contains glass, minerals, lithics and suggest indicating what you analyze (glass phase) later in the manuscript or insert "glass" geochemical composition of Pleistocene tephra layers...

We rephrased the sentence:

*There, glass phase geochemical compositions of Pleistocene tephra layers were recently systematically investigated for their stratigraphy and chronology within the scope of the Collaborative Research Centre 'Earth – Evolution at the Dry Limit' (CRC1211).*

**Line 42:** remove 'so-called' and just use the term volcanic 'ash layers' or 'tephra layers', no parenthesis needed (you already did so on line 23)

We rephrased the sentence, please see the comment on line 42-44 below.

**Line 42-44:** awkward sentences and suggest revising to be more concise. Suggestion: Volcanic ash deposits are found within many types of sedimentary successions and serve as excellent chronological and stratigraphic marker horizons. This makes them highly valuable for stratigraphic and chronological studies, such as those in geoscience and archaeology (Lowe, 2011), through the application of tephrostratigraphy and tephrochronology.

We rephrased the sentence:

*Volcanic ash deposits are intercalated within many types of sedimentary successions. This makes them highly valuable as isochronous marker horizons for stratigraphic and*

*chronological studies in geoscience and archaeology (Lowe, 2011).*

**Line 50**, these terms are becoming onerous and wonder if you should just refer to them as ‘Tephrochronology’ starting here? Suggest rewording: Tephrochronology is a well-developed and frequently used technique for correlating and dating geological sequences and events in many regions of the world including...

We followed your suggestion and now just refer to “tephrochronology” within the manuscript if both terms had been used.

**Line 55**: please add Alaska (GeoDiva, Cameron et al., 2022). Cameron, C.E., Crass, S.W., and AVO Staff, eds, 2022, Geologic database of information on volcanoes in Alaska (GeoDIVA): Alaska Division of Geologic and Geophysical Surveys Digital Data Series 20, <https://doi.org/10.14509/geodiva>, <https://doi.org/10.14509/30901>.

The GeoDiva database and the respective reference was added to the list of databases.

**Line 65-69**: Be clear what you mean by “pre-requisite” for tephra geochemical fingerprints as magma-crust interactions is too broad of a definition. I think you just mean that distinct geochemistry is ideal for discriminating tephra?

As requested by reviewer I, we rephrased that section.

*Geochemical variations specific to individual volcanoes and eruptions are driven not only by parental magma composition and the degree of crystallization, but also by the geodynamic evolution of the Andes. The spatial and temporal differences in the thickness and composition of the crust, led to varying degrees of magma-crust interactions and thus to variable/additional magmatic differentiation of individual eruptions (Kay et al., 2010; Brandmeier and Wörner, 2016; Burns and De Silva, 2023).*

**Line 274**: suggest rewording these sentences for clarity. Suggested rewording: “For homogeneous glass, SiO<sub>2</sub> concentrations obtained from EPMA-WDS data were used as the internal standard during LA-ICP-MS trace element data reduction. For samples with multiple glass populations, additional SEM-EDS analyses were performed and mapped to specific point data to provide internal standards for LA-ICP-MS trace element calculations.”

After a comprehensive review of the entire dataset, we re-examined the two samples for which LA-ICP-MS data reduction had been based on grain-specific SiO<sub>2</sub> values. We recognize that our previous description of this approach was unclear and, in part, inaccurate, and we sincerely apologize for this oversight. The grain-specific SiO<sub>2</sub> data in question were obtained during SEM-EDS sessions for which no secondary standard measurements are available. Although these values showed good agreement with the corresponding EPMA-WDS data of the sample, the lack of secondary standard data limits their analytical robustness. Consequently, we excluded these grain-specific SEM-EDS data and instead applied the median SiO<sub>2</sub> concentrations determined by EPMA-WDS consistently across all samples in the dataset as also SiO<sub>2</sub> concentrations appeared homogenous. The methods descriptions within the manuscript have been corrected.

**Line 298-300**: I am confused by this sentence. Clarify please. Also, were all major and minor oxides analyzed by EPMA or using both EPMA and SEM and if so, is this clear in the Db and have these methods been proven to be comparable on your 2 instruments?

We adjusted that paragraph to avoid confusion. Details about the analytical precision and accuracy of both instruments are given in the chapter about geochemical data quality and demonstrate the overall comparability of the data. Except for three samples, all samples discussed within this manuscript were analyzed by EPMA-WDS, which provides the basis for data classification.

**Line 310:** Is this 1 standard deviation or 2?

As requested by reviewer I, we rephrased that section. We had calculated the relative standard deviation using a one standard deviation. We have now changed this according to both reviewers' suggestion to relative two standard deviation (two standard deviation/mean).

**Line 425:** unclear what "For samples listed with an incomplete or missing geochemical characterization.... means? Do you mean those data are planned to be collected but are not in the db now? not sure this is worth mentioning?

Yes, we addressed the samples for which no complete (major, minor and trace element) composition is available at present. We deleted the sentence and integrated this information within the conclusion part of the manuscript.

**Line 426:** I assume new analyses of legacy samples are in the db and not the legacy data itself? Best to only include "best" data in the Db

As requested by reviewer I, we rephrased this section. In addition to newly acquired data for legacy samples, we also added existing legacy data within the database and flagged such questionable data as not reliable within the download file of the EPMA-WDS data. We did so to provide a most complete dataset accounting also for existing data. However, we see the point that flagging of the data might be overseen and thus have removed these entries to include only "best" data.

**Line 501:** do you mean that some tephros in the db were found across the Atacama Desert region? The use of "archive" made me think these tephros are found in other digital or other data archives but I think you mean they are widespread and found in the regional stratigraphy?

We used the term "archive" for different sedimentary deposits. As requested by reviewer I, we changed the sentence.

*Some tephra layers were found in different sedimentary archives (e.g., tephra layers of CG1, CG2, CG9).*

**Line 527:** this is really a "tephrochronological" approach - using tephros as time stratigraphic markers by correlating undated tephros to one with a determined age.

We changed the sentence accordingly.

*In some archives, tephrochronology also provides an independent validation of direct dating of host sediment.*

**Line 545:** ...available for download on or after 2027-10-21. The links all go to the TephAta website and not EarthChem. I appreciate that the data are uploaded to EarthChem repository as a back up in case the TephAta Db goes down and because EarthChem is a global accepted repository standard, but it would be nice to see what those data look like in EarthChem – did you use the Tephra templates provided in EarthChem?:

[https://earthchem.org/communities/tephra#tephra-templates.](https://earthchem.org/communities/tephra#tephra-templates)

EC works well for certain data types, such as geochemistry, but it does not store ALL tephra-related information in the database, including some of the data you collected. However, the tephra templates allow you to archive this information in a spreadsheet, even if not all fields are searchable within the database.

We apologize for the confusion regarding the data stored at EarthChem. The uploaded data had to be embargoed to allow data correction being requested within the review process. The data being uploaded at EarthChem was attached as supplementary dataset to this manuscript, somehow this information seemed to be not available within the review files. We have used

tephra-templates of EC for uploading geochemical data and provided an additional file summarizing the most important meta data of the samples. The embargo at EarthChem will be released once this manuscript is accepted for publication, so that a backup of the herein discussed data is available.

**Line 555:** Is IGSN automation a feature of TephAta? If so, how do you ensure legacy samples don't already have IGSN's.

Yes, the IGSN registration is an automated feature of TephAta working together with the GFZ Potsdam IGSN registration facility. So far, legacy samples included within the db, had no registered IGSN. However, we have now implemented a function within the TephAta data submission, which allows us to link the sample with an existing IGSN. If an IGSN is entered for a specific sample, no new IGSN will be minted.

**Line 559:** unclear what this means? SERNAEOMIN has 400 samples it is ready to upload to TephAta? Can you elaborate a bit here, are they waiting to publish their data and then enter it into TephAta?

We rephrased that paragraph.

*For samples listed with an incomplete or missing geochemical characterization, the pending major, minor, and/or trace element analyses data will be complemented within the successive analytical work of the CRC1211. Future expansions will progressively incorporate over 400 additional samples from SERNAGEOMIN and current CRC activities. This set of samples will cover a time interval from the Early Miocene to the Holocene and has a spatial extent from the Chilean coast to the Andes along 18-30°S.*

**Line 565:** Tephra community has been working with StraboSpot for the last several year to develop a tephra module in Strabospot following the tephra community best practices for field collection and this will align well with TephAta. There will be a workshop at EGU to demo the app and to get community feedback.

This will be of great value for simplifying the process of (meta-)data documentation of tephra layers and is very interesting. We could think of an interface to integrate that within an updated version of TephAta.

**Line 567:** be sure to include “glass” or glass phase geochemistry here to avoid confusion with whole rock composition of the parent material which of course is rarely rhyolite or at least is less evolved than the glass Geochem. Suggest rewording lines **567-569**: “The Geochemical characterization....“Major and minor ....” to “Tephra in this study have predominantly rhyolitic glass compositions. Major and minor element glass compositions can differentiate only some tephra layers, whereas most layers are better distinguished by their trace-element glass compositions.”

We changed the sentence as suggested.

I wonder if you are able to link any of these tephra to volcanic sources? I notice in the db itself under Tephra Equivalents that Volcano says N/A for everything.

This was also commented on by reviewer I. We avoided an in-depth discussion about potential volcanic sources of tephra layers at the present state, as the lack of suitable data (glass geochemical data, precise chronological data of young eruptions) from proximal volcanic deposits does not allow a robust correlation yet and is beyond the scope of the current paper, presenting the database. We plan to investigate the source of the identified tephra cluster within future work, including more proximal data and refined chronological information to ensure robust alignments. Therefore, we already integrated this function within TephAta as a placeholder to document the origin of tephra layers and link those samples to a specific volcano in the future. This will also allow us to search within TephAta for all eruptions of a specific

volcano.

## TECHNICAL CORRECTIONS

The db name, “TephATA” and ‘TephAta’ are used throughout and suggest changing them all to one usage. The Website looks like yet another, ‘Tephata’

We unified the name within the manuscript and the database website.

**Line 36:** what is meant by Leicher N., 2027 if we are only in the year 2026)? Does this have to do with an embargo until this paper is published? The data in EarthChem don’t appear to be visible.

Yes, this is related to the embargo of the data, in order to be able to incorporate review requested within the datasets. Files will become available after acceptance of this manuscript.

**Line 37:** change ‘origin’ to ‘originating’ from 91 tephra deposits...  
Changed as requested.

**Line 46:** Due to aeolian fractionation during volcanic ‘ash’ dispersal  
Changed as requested.

**Line 70:** change “discussed” to “thought”  
Changed as requested.

**Line 71:** delete “a” ensured good preservation of...  
Changed as requested.

**Line 73:** add or for use in extended ....  
Changed as requested.

**Line 75:** suggest rewording: "Correlation of tephra layers by their glass geochemistry is rare in the Atacama Desert region"  
Changed as requested.

**Line 80:** suggest rewording: A tephrostratigraphic framework using glass geochemistry and deposit age of widespread marker tephra layers is currently missing at the western side of the Andes.  
We rephrased the sentence.

**Line 85:** other places this is listed as CRC1211 without a space after CRC.  
We unified the name CRC1211 within the manuscript.

**Line 93-94:** suggest rewording: Within the CRC1211, tephrochronology was used for the first time to establish a time-stratigraphic framework for the Atacama Desert.  
We rephrased the sentence.

**Line 94.** Change, “The obtained data” to “these data are stored in a newly developed..., TephAta”  
Changed as requested.

**Line 95-97:** Suggest rewording: TephAta includes a wide variety of tephra metadata, from field

context to physical and chemical characteristics.

We rephrased the sentence.

**Line 334:** tephra samples are source from all types (add the 's') of sediment deposits

Changed as requested.

**Line 340:** the definition of "crypto" is invisible to the naked eye so crypto in parenthesis here is incorrect or you could update to "sub-cm to crypto tephra deposits." but sub-cm is not synonymous with crypto

We agree on that definition and have adjusted the sentence to clarify the meaning.

#### COMMENTS ON TephAta Db ITSELF (and data within)

I suggest that the authors focus on making sure the data in the db represents their best curated dataset and removes any questionable data. This means removing all data with low or high totals, those with missing method information and analytical standards data.

We thoroughly revisited all geochemical datasets and removed questionable analyses from the database and the data back-up stored at EC. All geochemical data is removed from the database, and the revisited datasets are currently being reuploaded. A compilation of all reviewed data will be made available within a revised version as supplementary material.

I suggest changing the name "Geochemistry" to "Glass Geochemistry"

We agree that the current datasets would suggest such renaming. However, the general design of TephAta was set to account for all different kinds of data, including data which might be stored in the future (e.g. compositional data of mineral phases). To guarantee that users are aware of which phase was analyzed, a two-fold declaration of the type of data within TephAta is requested. Within the sample meta-data description, users can select from a pre-defined list which kind of geochemical data was acquired (e.g. "EPMA-WDS, glass" or "EPMA-WDS mineral"). Further, within the given templates for uploading geochemical data, users are asked to define the phase being analyzed and which analytical method was applied. Therefore, we did not change the category name.

It would be nice to see more **sample descriptions** in the field like that under sample TA-7 – this is currently listed under the General tab/Comment but wonder if there is a more dedicated place to include a sample description that could be text based and be a catch all for thickness, etc. Putting this in a comments field feels a little out of place and think layer description or sample description would be better.

TephAta includes already the requested options for describing samples. Within the general sample tab, a general description can be given as comment, but also many information on how the sample was taken and what analyses were performed can be stored. More detailed sample descriptions are enabled within the subsequent categories. Details on thickness, color, continuity, texture, components and many other observations can be provided within the "Physical Properties" (former Morphology) tab. Here a mixture of predefined lists and text/number-based fields is given for sample description.

We updated the supplement material to document a better overview of the input forms within TephAta.

I am noticing that more fields show up if there is information to go in them, e.g., sample "CHU Tephra" has information under Analysis Details/Lab Split info: so it might be nice to explain in the manuscript that data only show up for fields that are filled in. Do you have templates for uploading site & sample data in addition to the geochemical data? I can only find the Geochem templates on the website.

We clarified within the text that only fields which contain data are shown on the website.

*Datasets stored within TephAta can be accessed through the categories: “sites” and “samples”. All data associated with a given sample or site are presented on a dedicated page that compiles and displays all shared entries.*

We also extended the supplementary material, improving the explanatory table and showing all input options, to provide a better overview of the type to be stored.

There is no automated data upload via template of site and sample information implemented within TephAta at present. This may be enabled in an updated future version of TephAta. However, in order that users can prepare documentation of such data, we now added a dedicated template form for download on the “TephAta Information” page (<https://www.crc1211db.uni-koeln.de/search/tephataInfo.php>). Users can use that form for collecting all necessary information, before entering such within the database.

I suggest changing all instances of the name of the Db tephata to TephAta including on the website. Left hand column of menus especially.

We unified the name within the website.

**Tephra Equivalents page:** Could this section be titled “Unique Tephra Layers” or something similar? The current wording feels a bit awkward, though it’s not a major issue. Also, the wording in the green “Equivalents” box says “List of eruptions with associated tephra samples,” which is helpful. Including similar explanatory text on the “Tephra Equivalents” page would improve clarity, perhaps noting that these may not represent unique or single eruptions, but rather tephra that are geochemically indistinguishable and considered equivalent or from the same source volcano at minimum.

We renamed this section into “Tephra Correlation Group” and added additional explanations to the respective webpage.

**Samples page:** When performing a search on the Samples page, I filtered by SiO<sub>2</sub> range and received a table. Could you clarify what “Title” refers to? Also, table headers like MME-CM or TE-CM are not immediately clear—there seems to be space to spell these out for better understanding. Similarly, does “Site” refer to a site ID, site type, or site location? The terminology is a bit confusing, and adding clarification would improve usability. If you’ve already considered this extensively, I understand, but clearer labels could add value for users. I do love that correlated tephra are in the output! Also so many great search filters here – awesome! Can you add IGSN to the sample search?

We reviewed all table headers to provide a better understanding of the terms, however available cell space is limited and headers were tried to kept short. We further added text with explanations to the top of the website and updated the mouse-over functions (explanations popping up if mouse is placed on header text). We also added an IGSN filter. (<https://www.crc1211db.uni-koeln.de/search/viewAllSamples.php>)

**Sites page:** is title the site ID name? might be better to call it Site ID rather than Title? What is meant by Identifier? I assume this is the site IGSN, can you call it that instead of identifier?

We adjusted the table headers as suggested.

**Clarification on IGSN Links and Registration:** When I click on the IGSN for sites or samples, it doesn’t seem to lead anywhere. Could you clarify which system was used to register these site/samples? For example, I checked SESAR for sample 19MEJ09 (IGSN #10273/GF1211S-4E), but it does not appear there. I haven’t tried other systems yet, but it seems there needs clarification on how samples and sites are registered with IGSN numbers.

Samples were registered via GFZ Data Services Potsdam. During set up of TephAta we encountered the same issue and contacted the IGSN committee to address that issue. To our knowledge, there is no global IGSN registration list, which allows that samples created by IGSN provider “A”, are automatically listed/found at IGSN provider “B”. Our latest information is that SESAR and the IGSN committee are working on a solution. We added a paragraph to the database description within the manuscript.

*If no IGSN (International Generic Sample Number) was assigned to a site or sample before registration within TephAta, a new IGSN will be minted and connected with the internal metadata upon data submission in TephAta by the GFZ Potsdam Data Services. This new IGSN will then be associated with the TephAta URL, providing a link to the full metadata released within the database. Existing IGSN IDs can be linked to a sample during data submission.*

**Templates:** I downloaded the templates from the website rather than those uploaded to the journal. When I open them, the defined lists for data fields with drop-down menus show an arrow but no actual options. I also received the following error when opening the downloaded file: **“UNABLE TO REFRESH – We couldn’t get the updated values from a linked workbook.”** I am noting this in case others encounter the same issue. It might help to include a readme file with the templates or a table of definitions, so users know exactly what each field means. There are good examples and definitions for the horizontal data, but the vertical columns (e.g., *Obligation IGSN?*, *Obligation DB?*) need clarification. Also, the *Extension Keywords/drop-down lists* row shows “N/A” for all LA\_ICPMS, but the spreadsheet actually contains several pick lists. Should those fields be marked as “Yes” or “No”? The geochemical data templates are excellent!

We updated the template files and removed broken links, unclear vertical columns etc. All information is now available within the description fields, in addition with information which fields are mandatory for successful data upload.

**Enter a new Sample:** I’d like to better understand what sample and site metadata are stored in the database. Could you make the interface for entering a new sample available for review purposes? Additionally: Is there a site and sample upload template?

We added an improved documentation about input forms to the supplementary material of this manuscript and provided these files also for download at the TephAta information site. As explained above, we also added template files for site and sample data, which allow specific data collection. However, a manual upload /input of this data is needed, but a direct template upload is considered for a future update of TephAta.

## COMMENTS ON SUPPLEMENTARY MATERIALS

### Supplementary Table 1:

General comment –include the list of drop down terms for each field that has a pick list.

We updated Supplementary Table 1 and added additional information on drop-down terms.

General comment – this would be easier to review if it were a table formatted to show Category, Field Name, Field type, Description, Pull Down Menu all on ONE page. I had a hard time lining things up to understand the definition of each term.

We apologize for the poor format of the table, which made it hard to access. We adjusted the supplementary material.

**Site** – does this mean Site type? If so can you call it “site type” and show the pick list or drop-down menus

The field “Site” opens via drop-down menu a list with Site IDs/names of all different sites listed within TephAta or allows to enter a “New Site”. By selecting an existing site, a (new) sample can be linked to its respective site. Site type is a separate input field (e.g. type of site like

riverbar), we clarified that in the description.

**Site title** – does this mean site ID? Suggest calling it “site ID” instead of “title”

We changed the name of the field to “Site name”.

**Site Additional Comments:** I think this is where some samples have a description of the deposit...? TA-7 for example but it would be nice to have a sample description or deposit/layer description field.

A clear distinction must be made between site and sample descriptions. Information entered as *site additional comments* refers exclusively to the site itself and does not describe individual samples. For example, sample TA-7 originates from site TA-7-8, which has its own site description independent of the tephra layers identified within the outcrop (sample specific information and relation to site are given on sample level).

The site input mask provides several dedicated fields for detailed documentation. The *site description* field is intended for a general overview, while more specific aspects should be entered in the corresponding fields (e.g., site spatial context, section thickness, geolocation type). The *additional site comments* field is for information that does not fit into the predefined categories (e.g., noting that site was only accessible due to roadwork etc.).

At the sample level, multiple fields are likewise available to ensure detailed and structured documentation of sample characteristics, as described above and in the revised supplementary material.

**Sample method vs sample collection method?** What is the difference? I see now that ‘Sample Method’ is the position of sample from within a strat layer...that is confusing and suggest replacing ‘method’ with ‘stratigraphic position’.

The “sample method” is following the tephra best practice recommendations, defining on how a specific tephra sample was taken (e.g. channel through entire stratum, handpicked clasts, etc.). The “sample collection method” addressed how the sample was taken in general (e.g. by coring or manually by hammer). We changed the latter one to “Sample recovery technique” to avoid confusion.

There is no sample description – seems like an oversight.

We assume you refer to the fact that there is no dedicated tab called sample description. Information about the sample is entered at two tabs. The section “Sample” includes basic/meta information of a sample (names, what, who, when, where and how was sampled), the actual physical description on a macro- and microscopic scale is given under the tab morphology (now called Physical properties).

**Morphology** – In tephra science, I typically associate morphology with grain shapes. Sup Table 1 is the first place I see what you mean, and it seems that the metadata grouped under “Morphology” actually includes two distinct types of information: the first 17 terms relate to layer characteristics and starting with “microscoped fraction,” the rest are microanalytical details. To make this clearer for users, these could be divided into at least two subfields: “Layer” and “Physical Microanalytical”, this breakdown would provide a more intuitive structure.

We renamed the category “Morphology” to “Physical properties” and restructured it into macroscopical and microscopical observations.

**Stratigraphy** – these look like geochronology metadata

We renamed this tab to “Chronostratigraphy”.

## Data file supplements

The 2 geochemical data files are the tephra templates from EarthChem (established by the tephra community)! Great!

### DATA\_EDS\_WDS:

There are some metadata missing that could be included like **sample description** of the sample material analyzed which would add value; **Analyst** is listed for some but not most?; **Beam diameter** is missing for some analysis – why?; **Data line type** – what is meant by “line”-many samples have this notation? Are these the SEM-EDS data? **Sample mount** – are there not names for all mounts?

We thoroughly checked the dataset and added all such information if available.

Some Method DOIs are links and others are not can you make them all links

Missing links were added.

Great that the table clearly distinguishes which data come from EPMA-WDS and which from SEM-EDS. That clarification is very helpful, as it was initially unclear until I noticed the information in the far-right column (column BB).

I don't see where you show secondary standard analyses on the SEM-EDS? This is very important and needed to show that your SEM-EDS and EPMA-EDS data are comparable.

SEM-EDS secondary reference standards were available for two SEM-EDS sessions, which also documented the comparability with EPMA-WDS data. Data of one SEM-EDS session data without secondary standard data has been removed.

### TephAta\_Sample Info table

The IGSNs all point to TephAta database and not to another IGSN repository like DataCite?

IGSNs are created within TephAta by GFZ Data Services Potsdam and the IGSN doi registration is issued by DataCite. At DataCite you can search for an IGSN, which resolve basic meta data and the (doi) link to the full meta data stored within TephAta/ GFZ Potsdam. This seems common practice, since also for samples registered via SESAR, DataCite provides just a link to the full metadata set stored at geosamples.org and does not own the metadata.

Brandmeier, M. and Wörner, G.: Compositional variations of ignimbrite magmas in the Central Andes over the past 26 Ma — A multivariate statistical perspective, *Lithos*, 262, 713-728, <https://doi.org/10.1016/j.lithos.2016.07.011>, 2016.

Breitkreuz, C., de Silva, S. L., Wilke, H. G., Pfänder, J. A., and Renno, A. D.: Neogene to Quaternary ash deposits in the Coastal Cordillera in northern Chile: Distal ashes from supereruptions in the Central Andes, *J. Volcanol. Geotherm. Res.*, 269, 68-82, <https://doi.org/10.1016/j.jvolgeores.2013.11.001>, 2014.

Burns, D. H. and de Silva, S. L.: Andesites and evolution of the continental crust: Perspectives from the Central Volcanic Zone of the Andes, *Front. Earth Sci.*, 10, <https://doi.org/10.3389/feart.2022.961130>, 2023.

Dunai, T. J., González López, G. A., and Juez-Larré, J.: Oligocene-Miocene age of aridity in the Atacama Desert revealed by exposure dating of erosion-sensitive landforms, *Geology*, 33, 321-324, <https://doi.org/10.1130/G21184.1>, 2005.

Evenstar, L. A., Mather, A. E., Hartley, A. J., Stuart, F. M., Sparks, R. S. J., and Cooper, F. J.: Geomorphology on geologic timescales: Evolution of the late Cenozoic Pacific paleosurface in Northern Chile and Southern Peru, *Earth Sci. Rev.*, 171, 1-27, <https://doi.org/10.1016/j.earscirev.2017.04.004>, 2017.

Hopkins, J. L., Bidmead, J. E., Lowe, D. J., Wysoczanski, R. J., Pillans, B. J., Ashworth, L., Rees, A. B. H., and Tuckett, F.: TephraNZ: a major- and trace-element reference dataset for glass-shard analyses from prominent Quaternary rhyolitic tephra in New Zealand and implications for correlation, *GChron*, 3, 465-504, <https://doi.org/10.5194/gchron-3-465-2021>, 2021.

Kay, S. M., Coira, B. L., Caffè, P. J., and Chen, C. H.: Regional chemical diversity, crustal and mantle sources and evolution of central Andean Puna plateau ignimbrites, *J. Volcanol. Geotherm. Res.*, 198, 81-111, <https://doi.org/10.1016/j.jvolgeores.2010.08.013>, 2010.

Lowe, D. J.: Tephrochronology and its application: A review, *Quat. Geochronol.*, 6, 107-153, <https://doi.org/10.1016/j.quageo.2010.08.003>, 2011.

Marquardt, C., Fornari, M., Lavenu, A., Easton, G., Ortlieb, L., Ritz, J.-F., and Philip, H.: Volcanic ash dating from the Mejillones Peninsula (23°S): Implications for the Neogene outer fore-arc stratigraphy, tectonics and volcanic relationships, 6th International Symposium on Andean Geodynamics, Barcelona, 12-14 September 2005, Extended Abstracts: 477-480, 2005.

Pearce, N. J. G.: Towards a protocol for the trace element analysis of glass from rhyolitic shards in tephra deposits by laser ablation ICP-MS, *J. Quat. Sci.*, 29, 627-640, <https://doi.org/10.1002/jqs.2727>, 2014.

Portnyagin, M. V., Ponomareva, V. V., Zelenin, E. A., Bazanova, L. I., Pevzner, M. M., Plechova, A. A., Rogozin, A. N., and Garbe-Schönberg, D.: TephraKam: geochemical database of glass compositions in tephra and welded tuffs from the Kamchatka volcanic arc (northwestern Pacific), *Earth Syst. Sci. Data*, 12, 469-486, <https://doi.org/10.5194/essd-12-469-2020>, 2020.

Ritter, B., Mohren, J., Binnie, S. A., Wennrich, V., Dunkl, I., Albert, R., Gerdes, A., LoBue, S., and Dunai, T. J.: Shaping the Huara Intrusive Complex in the Hyperarid Atacama Desert-Erosional Near-Stasis Contrasting High Topographic Gradients, *J. Geophys. Res.: Earth Surf.*, 128, e2022JF006986, <https://doi.org/10.1029/2022jf006986>, 2023.

Tomlinson, E. L., Arienzo, I., Civetta, L., Wulf, S., Smith, V. C., Hardiman, M., Lane, C. S., Carandente, A., Orsi, G., Rosi, M., Müller, W., and Menzies, M. A.: Geochemistry of the Phlegraean Fields (Italy) proximal sources for major Mediterranean tephra: Implications for the dispersal of Plinian and co-ignimbritic components of explosive eruptions, *Geochim. Cosmochim. Acta*, 93, 102-128, <https://doi.org/10.1016/j.gca.2012.05.043>, 2012.

Vásquez, P. and Sepúlveda, F. A.: Cartas Iquique y Pozo Almonte, región de Tarapacá, Servicio Nacional de Geología y Minería, Carta Geológica de Chile, Serie Geología Básica, 162-163, Santiago, Chile, 114 p., ISSN:0717-7283 Inscripción No. 235.688, 2013.

Wallace, K. L., Bursik, M. I., Kuehn, S., Kurbatov, A. V., Abbott, P., Bonadonna, C., Cashman, K., Davies, S. M., Jensen, B., Lane, C., Plunkett, G., Smith, V. C., Tomlinson, E., Thordarsson, T., and Walker, J. D.: Community established best practice recommendations for tephra studies—from collection through analysis, *Sci. Data*, 9, 447, <https://doi.org/10.1038/s41597-022-01515-y>, 2022.