Interactive comment on “Petrophysical and mechanical rock property database of the Los Humeros and Acoculco geothermal fields (Mexico)” by Leandra M. Weydt et al.

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Author’s comment on “Referee comment 2 – Review on Petrophysical and mechanical rock property database of the Los Humeros and Acoculco geothermal fields (Mexico)” by Léa Lévy

We would like to thank Léa Lévy as referee #2 (R2) for her valuable comments and suggestions to improve our manuscript. In the following sections, we would like to address the two main remarks of R2 regarding 1) “the lack of electrical measurements and the implications for statistical analyses and MT/TEM/DC survey interpretations“ as well as 2) referencing to similar studies and a more detailed explanation of the limitations of this specific database. More detailed questions regarding specific text sections are listed below and we hope that our reworked manuscript provides the requested clarification.

General remarks:

Referee 2 – Remark 1: *"More explanations about the lack of electrical measurements (50 samples versus 1000-1500 for all other properties) and the implications for statistical analyses and MT/TEM/DC surveys interpretations. MT and TEM are among the most common methods (if not the most) used in geothermal exploration, so this discussion is critical to justify the usefulness of your paper. The paper also should help the reader find ways to overcome this gap. Additionally, the use of ERT for inferring the resistivity of samples is not a state-of-the-art method and it is not clear how many of the 50 samples are inferred from ERT. Especially because 50 samples have a formation factor, which I guess you cannot obtain with only ERT measurements. More clarity is needed here."*

Answer: The database presented in our manuscript is the result of a joint effort of multiple project partners of the GEMex project working on the task of petrophysical rock characterization. We joined forces so that each partner involved in this task was performing the measurements which were available at their institutions and which were part of their main expertise. Given the different amount of person-months allocated to the individual partners for each task, different numbers of measurements could be performed by the different partners. In the particular case of the electric resistivity measurements, the availability of measurement devices and logistical problems in the project were the main reason for the comparatively "low" number of these measurements. Additionally, the main purpose of this database was not to provide input data for geophysical exploration methods such as MT/TEM/DC and their interpretation but to provide input data for numerical reservoir models mainly focussing on their thermo-hydro-mechanical behaviour during exploitation.

Regarding electric resistivity measurements, the 50 existing measurements with a formation factor in the database were analyzed on plugs in the laboratory. Field measurements were performed on 24 samples, which are marked as 'field samples' in the database. However, we recognized that the electric resistivity measurements of these samples were lacking in the database (so far only the P-wave measurements were included), which might be the reason for the referee's questions. To accomplish the reviewer observations and given the underlined uncertainty in field ERT data, the electric resistivity data inferred from ERT and the corresponding text passage will be removed from the database and the manuscript.

Hence, about 15% of the outcrop samples included in the database were analyzed for electric resistivity covering several lithologies from the basement to the caprock. We think that this amount of data is already supporting MT/TEM/DC survey interpretations. However, we agree, that it would have been very useful for the statistical analysis of electrical properties of the investigated samples and their usefulness for MT/TEM/DC survey interpretation if we would have done a more comprehensive measurement programme for these properties as well. But as also stated in our manuscript, the reservoir properties are strongly governed by the tectonic overprint and the resulting faults, damage zones and fracture networks locally increasing the porosity and permeability of the geological succession and as such act as conduits for reservoir fluids, which would also be the strongest detectable anomalies in electromagnetic surveys. See also further comments below.

Referee 2 – Remark 2: *"(ii) Clearer aim and context. References and comparison to recent, similar and complementary studies are lacking. Especially to feed the discussion on how to overcome limitations of this specific database. I have suggested a few studies that I know of and consider complementary."*

Answer: The arguments of referee 2 strongly focus on electric resistivity measurements and MT/TEM/DC survey interpretation. As mentioned above, this was not the main purpose of the GEMex project and this study. Referee 2 considered several interesting articles about Iceland, which predominantly cover the interpretation of electrical resistivity tomography (ERT), gravimetric and seismic surveys (sometimes in context with porosity, density or permeability data), and some detailed analyses of electric resistivity and magnetic susceptibility measurements on a small number of rock samples regarding super-critical conditions or hydrothermal alteration. Since the GEMex project focuses on deep super-hot geothermal systems, findings and raw data from the Krafla geothermal field are indeed good complementation. However, the suggested articles barely contain rock properties or only focus on detailed analyses of one single parameter. Thus, they do not represent a "database" as defined in our study, in which a high number of samples were analyzed for a wide variety of parameters. As our study focuses on rock properties associated with volcanic settings and/or super-hot geothermal systems, we already included several studies in our manuscript presenting newly generated rock property data from different study areas that fit the context of our work, but also studies that represent petrophysical rock characterization and reservoir characterization in a wider context.

Introduction:

General literature: 1. Schön (2015) = general introduction into rock properties; 2. Bär et al. (2020) = recently published Image database containing digitized rock property data from published articles; 3. Clauser and Huenges (1995) = average thermal conductivity values for minerals and specific rock types, 4. Sass and Götz (2012) = thermofacies concept considering thermal conductivity and permeability data for reservoir characterization; 5. Howell et al. (2014) = the application of outcrop analogues in geomodelling, upscaling; 6. Linsel et al. (2020) = chemical and petrophysical characteristics of sandstone on the lithofacies scale, Germany; Hydrothermal alteration: 7. Mielke et al. (2015) = thermophysical properties, Tauharo geothermal fiel, New Zealand; 8. Pola et al. (2012) = petrophysical and rock mechanical properties, Solfatara crater, Ischia Island and Bolsena volcanic zone, Italy; 9. Mordensky et al. (2019) = petrophysical and rock mechanical properties, Mt. Ruapehu, New Zealand; 10. Durán et al. (2019) = petrophysical properties, Ngatamariki geothermal field, New Zealand; Diagenetic processes: 11. Aretz et al. (2015) = petrophysical properties related to mineral content, depositional environment and diagenesis, sandstone, Upper Rhine Graben, Germany; 12. Weydt et al. (2018a) = petro- and thermophysical properties related to dolomitization, Devonian aquifer systems, Alberta; Literature related to the study area in Mexico: 13. Weydt et al. (2018b) = primilary results of the GEMex project; 14. Contreras et al. (1990) = petrophysical and rock mechanical properties, reservoir core samples, Los Humeros; 15. García-Gutiérrez and Contreras (2007) = thermal conductivity measruements, reservoir core samples; Los Humeros; 16. Canet et al. (2015) = petrophysical properties, reservoir core samples, Acoculco.

Project framework: 17. López-Hernández et al. (2009) = exploration study regarding hydrothermal alteration, Acoculco; 18. Lepillier et al. (2019) = rock mechanical properties obtained on samples from Las Minas used for DFM modeling; 19. Kummerow et al. (2020) = electrical and hydraulic properties at supercritical conditions; 20. Deb et al. (2019c) = Laboratory fracturing experiments on big blocks from Las Minas; 21. Lacinska et al. (2020) = fluid-rock reactions analyzed on outcrop and reservoir core samples from Los Humeros.

Discussion: 22. Lenhardt and Götz (2011) = petro- and thermophysical properties of volcanic rocks, Central Mexico; 23. Pola (2014) = rock mechanical properties , Solfatara crater, Ischia Island and Bolsena volcanic zone, Italy; 24. Mielke et al. (2016) = petro- and thermophysical properties, Taupo Volcanic Zone, New Zealand; 25. Heap and Kennedy (2016) = scale-dependent permeability of andeistic lavas, Mt. Ruapehu, New Zealand; 26. Navelot et al. (2018) = petrophysical, thermophysical, dynamic mechanical properties of various volcanic rocks and the impact of hydrothermal alteration, Guadeloupe Archipelago, West Indies, Antilles; 27. Stimac et al. (2004) = petrophysical properties of andesitic lavas, Tiwi geothermal field, Philippines; 28. Siratovich et al. (2014) = petrophysical and mechanical properties of andesitic lavas, Rotokawa geothermal field, New Zealand; 29. Ólavsdóttir et al. (2015) = reservoir quality of volcaniclastic units, Faroe Islands, northeast Atlantic; 30. Cant et al. (2018) = permeability of different volcanic rocks, Ngatamariki geothermal field, New Zealand.

Since most of these studies are published later than 2010, we don’t see a lack of ‘recent and similar’ studies cited and discussed in our manuscript. However, we agree that literature from Iceland would be good complementation and we added some of the below-mentioned studies to the discussion. Furthermore, we agree that a short section regarding other extensive databases (like oil and gas databases, petrological or rock chemical databases) could be very beneficial for the reader and we added a short section to the manuscript. Further comments are included in the sections below.

Specific comments:

Comments on additional references:

Referee 2: *“Is this database only intended at interpreting geophysical datasets in the two corresponding areas in Mexico, for this corresponding deepEGS exploration project? Or do you see possibilities to use this database at other geothermal fields, for different geothermal exploration projects?*

→ *If this is only for the present exploration project in Mexico, are you then suggesting that such extensive data collection be done for every geothermal system to be explored? It would be interesting to get an idea of how much resource it requires, compared to other exploration costs. Is it realistic? Are we going to need public funds for every new geothermal exploration project? Or is there a point where we will have hopefully collected enough petrophysical data and run sufficient statistical analyses, to be able to build experience from one field to the other, and even compare fields world-wide?*

→ *If you consider that this database can be used in other contexts than in Mexico, it would be very valuable to elaborate a bit. How can a given petrophysical dataset be used to better understand reservoir behavior? To interpret geophysical data at other places?“*

Answer: The main purpose of the GEMex project is to develop new and transferable approaches for the exploration and development of super-hot and unconventional geothermal systems worldwide. Thus, this database not only intends to provide comprehensive and detailed input data for numerical modelling and to support the interpretation of geophysical surveys performed in Acoculco and Los Humeros, but also to serve as an example for other and future geothermal exploration studies.

The accuracy of 3D geological models strongly depends on the amount and quality of input data, which are often lacking especially in early exploration stages. Depending on the scale of the model (global or regional) or for a first assessment, it is often sufficient to use literature data from a similar geological context (for example using this data for other volcanic settings in the TMVB or elsewhere), also from an economical point of view. However, since our data and data from literature have shown, that rock properties strongly depend on the original texture, mineral composition, pore and fracture distribution of the rocks as well as tectonic, diagenetic and metamorphic processes resulting in a high geological variability, it is always favorable or necessary to investigate the relevant key formations in a study area – especially for small-scaled investigations it is deemed necessary. Outcrop analogue studies represent a cost-effective approach to investigate the different geological formations in the study area and should be included in exploration programs, especially in greenfields, where the overall knowledge of the geological setting is still low. Of course, the extent of such studies and the amount of data that need to be collected strongly depends on the size of the study area and the purpose of the project. However, when generating new data, it is necessary that results from different institutes or disciplines are uniform and can be correlated with each other. Therefore, the coordination of field work and laboratory measurements to combine different disciplines, as it has been performed in this study, enabled the compilation of this large amount of data and also reduced costs in the field and for the shipment.

In addition, the compilation of such datasets and the creation of databases also always represents a learning curve. Since super-hot or supercritical geothermal systems are a relatively new topic and operating and drilling into these systems is very challenging, we are still at a point, at which we need to better understand the processes triggering these systems. Finding similarities between several systems, provides the possibility to transfer knowledge, exploration and exploitation approaches/technologies. With respect to our study, e.g. the andesitic lavas of the geothermal reservoir in Los Humeros seem to be very similar to the Rotokawa andesitic lavas of the Rotokawa geothermal field in New Zealand (Siratovich et al., 2014) regarding the type and degree of hydrothermal alteration and rock properties. Furthermore, thermal weakening of carbonatic basements as described in Heap et al. (2013), was also observed in the few available reservoir core samples from Los Humeros and Acoculco. A more general finding is, that these systems are predominantly fracture controlled. These information are very valuable when it come to modelling. Therefore, it is indeed the objective of such databases, as the one suggested by us, to compile a large amount of data to at one point be able to draw conclusions also for other fields based on sufficient statistical evaluation.

Referee 2: *"Regardless the answer to the question above, I think it is necessary to put this study more in context with similar studies. It is not the first time that such a massive effort is made in the context of high-enthalpy geothermal exploration. I can see that you refer to the P3 database made in the frame of IMAGE project, where the focus was on Iceland and Italy. I think it is critical to expand a bit on the differences and on the coherence between the two projects / databases. Why is this new database necessary after the one in the IMAGE project? How are they complementary? What results from IMAGE have convinced you that making such a database was useful? This would be a useful addition at lines 80-87."*

Answer: We agree that it would be beneficial for the reader to point out to similar extensive databases and we will add a short section to the manuscript. The IMAGE database (Bär et al., 2020) collected, digitized and organized rock property data of 316 research articles and student theses including 75.573 data points of 28 different rock properties analyzed on a wide variety of lithologies worldwide. While the IMAGE database is an important resource to enhance future modelling approaches and significantly increased the availability of standardized rock properties, it only contains very limited number of data points or parameters for each formation or area investigated. Furthermore, a detailed sample description is not always available. The usage of data from the IMAGE database was not sufficient for the purpose of the GEMex project regarding the level of detail and the geological complexity in the study area.

In contrast, the database presented in this manuscript, contains more than 31.000 data points and 34 different parameters for one study area only. The main difference to the IMAGE database is, that all samples were analyzed the same way. Whenever possible, each parameter was analyzed on each plug. This approach significantly simplifies and improves statistical analyses and allows for correlation between different parameters. While recent research articles usually focus on one single target formation or a specific rock type, this database covers all relevant geological formations from the basement to the caprock covering a wide range of sedimentary, volcanic, igneous and metamorphic rocks. Also the sampling strategy (collecting samples from the same formation from different outcrop locations within the study area) lead to an improved understanding of the spatial variability of each individual unit. The amount of data and the level of detail presented in this study significantly improved the geological understanding of the study area, but also helps to better understand the relation between different rock parameters and how they are affected by different processes (e.g. fracturing or hydrothermal alteration). This is useful to derive general trends (also in combination with other data, IMAGE) for e.g. numerical modelling or to go one step further and use such data to train machine learning algorithms for rock property prediction.

Referee 2: *Suggestions of additional references*

"Imaging the magmatic system beneath the Krafla geothermal field, Iceland: A new 3-D electrical resistivity model from inversion of magnetotelluric data" → Interpret MT inversions at geothermal fields using petrophysical calibration (especially temperature dependent measurements).

"New Conceptual Model for the Magma-Hydrothermal-Tectonic System of Krafla, NE Iceland" https://www.mdpi.com/2076-3263/10/1/34 → Shows how conceptual models are regularly updated in light of new petrophysical understandings

Study related to both IMAGE and GEMEx projects: "Electrical resistivity tomography and time-domain induced polarization field investigations of geothermal areas at Krafla, Iceland: comparison to borehole and laboratory frequency-domain electrical observations" https://academic.oup.com/gji/article-abstract/218/3/1469/5497301 → Interpret DC/IP inversions based on petrophysical measurements on core samples at the exact same site. Discussion on upscaling with in particular comparison of samples to borehole logging and analyses of in-situ versus laboratory temperature differences.

"A probabilistic geologic model of the Krafla geothermal system constrained by gravimetric data" https://geothermal-energy-journal.springeropen.com/articles/10.1186/s40517-019-0143-6

→ Statistical analysis of the link lithology versus density, and use to interpret gravity data. Could be cited around l. 79.

"Subsurface imaging of water electrical conductivity, hydraulic permeability and lithology at contaminated sites by induced polarization" https://academic.oup.com/gji/article/213/2/770/4816733

→ Lithology and permeability characterization in Denmark using petrophysical calibration based on extensive laboratory database (sedimentary context)

Answer: This study focuses on contaminated groundwater of a very shallow sand and clayrich aquifer in Denkmark. Our study focuses on deep high-enthalpy geothermal reservoirs and rock properties. We don't see any connection between these two studies.

You are saying in the introduction that data are distributed in different places (l.72-79), which makes their use complicated. But if this database is intended to be used in a more general manner than just in this project in Mexico, then there needs to be a (short) section on other similar database and how they can be combined. It could be in the discussion as well. I would also add references, either in the introduction (near l.72-79) or in the discussion, to data collection presented in separated papers or PhD thesis, provided that the data collection is significantly large and well-presented and contains consistent data to be comparable to your database, of course. That way the reader will know where to find complementary information, if he needs, e.g. in the IMAGE database or in other articles. A few suggestions below.

"Modification of the magnetic mineralogy in basalts due to fluid–rock interactions in a high-temperature geothermal system (Krafla, Iceland)" (see Table A1) https://academic.oup.com/gji/article/186/1/155/697067

In relation to IMAGE project and to geophysical interpretations above: "Electrical conductivity of Icelandic deep geothermal reservoirs up to supercritical conditions: Insight from laboratory experiments" (numerous tables and empirical laws for extrapolation)

Also in relation to IMAGE project and to geophysical interpretations above:" The role of smectites in the electrical conductivity of active hydrothermal systems: electrical properties of core samples from Krafla volcano, Iceland" https://academic.oup.com/gji/article-abstract/215/3/1558/5076040

Subsurface imaging of water electrical conductivity, hydraulic permeability and lithology at contaminated sites by induced polarization -> kontaminiertes Grundwasser in Dänemark, sand and clays

Answer: As mentioned above, we agree that it would be beneficial for the reader to point out further extensive databases. Some of the suggested research articles represent good examples of how rock property data can be used to interpret geophysical surveys and we will add some of the references to the discussion.

Comments on the structure of the database:

Referee 2 – line 1: "*The abstract could be shortened. I don't think the details on number and locations of samples are necessary, the two paragraphs l. 41 to l.53 could be significantly reduced.*"

Answer: We agree that the abstract should present the content of the paper in an informative but concise manner. However, the paragraphs from lines 41 to 53 shortly describe the aim of the study, where and how the samples were collected and analyzed. This information is essential for the reader to quickly understand the geological context and to estimate whether the data might be useful for their interests or not. Furthermore, the listing of the analyzed parameters is of great importance for people actually working on databases or searching for specific data. Since the length of the abstract is far below 500 words and this paper represents a database in a data journal, we see no need for further changes here.

Referee 2 – line 595: "*The discussion is a bit overwhelming and seems to mix results and conclusions. It could be re-organized in different sub-sections, e.g.*

o (i) how is this database useful (see detailed questions suggestions above I think this section should be greatly enhanced and developed compared to how it is now)

o (ii) what are the limitations and pitfalls and how to overcome them. More clarity in the discussion would help the reader feel more confident about in which contexts it is "safe" to use the database and in which contexts these data should be treated more carefully. "

Answer: The discussion already describes why the data is useful and mentions several examples of how the data was used and will be used within the scope of the GEMex project or can be used for other applications. We also discussed several limitations regarding the modeling of the Los Humeros and Acoculco caldera complexes or other future applications. Since this database allows for a wide range of future applications, it is not possible and also not the aim of this database to discuss all possible limitations that might come along with using this data. The samples and applied methods are well described and future users need to verify themselves whether this data are useful for their purposes or not. Therefore, we see no need in completely re-organizing this section. However, we agree that it would be beneficial for the reader to add more examples of how rock properties can be used in exploration studies and we added a short section to the first part of the discussion. We also improved the discussion regarding the varying number of measurements per analyzed parameter.

Comments on "Material and methods":

Referee 2 – line 442: *"were executed in a similar way with an impedance spectrometer"*

→ *you present three different types of electrical measurements, they are not that similar. Especially the "estimation from electrical resistivity tomographies performed in the sampling areas" l. 440. This is not state-of-the-art practice, so I would be careful here. How do you evaluate if the different types of measurements can be safely merged together? Have you tried different categories of measurements on the same samples? Alternatively, the different methods could be clearly presented in the database (different columns / specific column for different methods). It is not clear to me where the "field samples" using ERT values are shown? Does this mean that people will be using ERT values to calibrate future MT inversion? Shouldn't that rather be handled by joint inversion? ERT has its own issues (equivalences, DC static shift, convergence of inversion) so the value of these data will strongly depend on how the ERT was carried out (electrode spacing, geometric factor, current injected, presence of background noise, misfit of the inversion). It can be a good idea to include electrical measurements from ERT in the database, especially if you have a lot of ERT surveys and few samples in the corresponding area, but they should be much more clearly explained. As a potential user of your database, I wouldn't use ERT values for calibration if I don't know how they have been obtained."*

Answer: In both laboratories, the electrical resistivities were measured with 4-electrode layouts. Although at GFZ sample resistivities were gained from measurements with an impedance spectrometer, SIP data are not part of the publication, and given resistivities are related to a fixed frequency of 1 kHz. Nonetheless, we recognized an inconsistency in the database, as resistivities were measured at UNITO for saturation with a 1000 µS/cm-fluid, while for GFZ those resistivities were given for saturation with a 10 mS/cm-fluid. To make the dataset comparable we changed the database and now all resistivities at saturated conditions are related to measurements at 1 mS/cm fluid conductivity. Unfortunately, it was not possible to perform a statistically verified evaluation of the different measurement methods and there is only a small overlap of the sample sets sent to GFZ and UNITO (about 3 samples). However, both institutes mainly analyzed the same lithologies and the individual samples were collected from the same outcrops or at least the same sampling area. Hence, we think that the measurements of both institutes are comparable.

We completely agree with referee 2 with respect to the uncertainties and limitations of ERT. As explained above, the electric resistivity inferred from ERT data were accidently missing in the database. However, we decided to follow the arguments of referee 2 and will not include field measurements.

Adding further columns with respect to the adopted methodologies will in our opinion reduce its visibility. As explained in the manuscript, the column 'Institution' in the databse is used to relate to the applied measurement methods. We, therefore, would prefer to not include further specifications here. We are available to perform this if the reviewer deems this mandatory for publication.

Referee 2 – line 449: *"The error of measurements at dry conditions is 1.5% on average"*

→ how did you calculate it? It should be explained clearly. It is far from trivial to estimate this uncertainty. See examples below on the different sources of systematic errors and uncertainties in electrical measurements on rock samples.

Answer: We agree with the reviewer and have modified the corresponding text passage.

Comment on "Status of the database":

Referee 2 – line 563: *"This section presents a lot of numbers, hard to follow, maybe a table would be better?"*

Answer: This section was intended to present an overview of the amount of data presented in the database regarding the study area, model units, and analyzed parameters. Therefore, one table (Table 2) and two figures (Fig. 6 and Fig. 7) were included. Since the two paragraphs in this section are relatively short, we see no need to add another table considering the already critical length of the manuscript.

Comments on "Discussion":

Referee 2 – line 600: *"The high number of analyzed plugs and samples enables detailed statistical and spatial geostatistical analyses on different 600 scales (plug, sample, outcrop, formation or model unit), spatial evaluation of the results in 2D or 3D or the validation of different analytical methods."*

–> Electrical measurements were only made on 50 samples (Table 2), compared to 1000-1500 samples for all other properties. Is it sufficient for statistical analysis? Does it mean that this database has some specific limitations for interpreting MT/TEM inversions?If so, you should clearly state it and suggest how to overcome this issues (e.g. use data from IMAGE dataset or other studies mentioned above, where more than 100 different samples are presented per study, with all relevant mineralogical and petrophysical properties).

–> Why "only" 50 samples have electrical measurements? Some specific issues/limitations, maybe too time-consuming or expensive? I think it is totally normal to have limitations but it is important to the reader to understand the causes of this huge difference.

–> This is even more important given that some (how many??) of these 50 measurements are actually inferred from ERT and not direct laboratory measurements.

Answer: As explained above, all 50 electric resistivity measurements included in the database were obtained in the laboratory. The differences in the number of analyzed samples were caused by the availability of measurement devices and logistical problems within the project (e.g. shipment of equipment for the fieldwork, delay in the shipment of the samples back to Europe). Only two laboratories were equipped with appropriate measuring devices. Moreover, a limited amount of sample material had to be distributed between the partners. To summarize, the limitation of resistivity data resulted from a combination of logistical issues and time-consuming measurements.

The same accounts for specific heat capacity, fracture-toughness and triaxial measurements, which require a specific sample size and/or are relatively time-consuming and for which only one appropriate device was available in the consortium. For example, to obtain cohesion and friction angle, a minimum of three large plugs with a diameter of 55 mm and a length of 110 mm are required. This is a lot of sample material considering the sample preparation procedure (it is not easy to drill such large plugs as most of the samples contained a high number of fractures) and the extra effort to obtain such large boulders in the field (very limited access to the outcrops and requires a lot of equipment). Likewise, one single specific heat capacity measurement takes 24 hours. Since more than 200 samples were analyzed for this study in the end, it requires more than a year to obtain this amount of data. As a consequence, this parameter was obtained only once per sample, while other parameters were analyzed on each plug. This means that the total number of measurements per parameter given in Table 2 is not a criterion for "high or low number of measurements". As mentioned above, about 15% of all outcrop samples included in the database were analyzed for electric resistivity measurements. This amount of data usually fills a common research article and we think that it already supports the interpretation of TEM surveys as it covers all relevant lithologies in the study area. Therefore, we don't see a critical issue here as claimed by referee 2, although we agree that further data would be beneficial to improve statistical evaluation. We added a corresponding statement to the discussion.

Referee 2 – line 608: "*So far, only a few geothermal exploration studies in volcanic settings provide rock properties analyzed on [. . .] reservoir core samples".*
–> There are more than few available. See references above and many other references.
I think you should re-consider the structure and arguments of the discussion: see my other comments above. As I see it, the added value of your study is to provide a ready-to-use dataset for a specific exploration case + show and discuss how it can be used / not used in the future. Providing additional physico-chemical properties of volcanic rocks is of course a valuable side-effect. But it would not be sufficient as a single aim, because there are already a lot of data available, in particular in relation to IMAGE project."
Answer: We agree that this sentence can be interpreted in different ways and should be specified. Compared to siliciclastic or carbonate basins used for oil and gas exploration, the amount of petrophysical and mechanical rock property data for volcanic settings in the context of high-enthalpy geothermal systems is less documented. Furthermore, the effect of hydrothermal alteration and metamorphic processes on the rock properties is only addressed in a few studies so far (Pola et al., 2012, Frolova et al., 2014, Mielke et al., 2015, Navelot et al., 2018, Mordensky et al., 2019, Heap et al., 2019, Delayre et al., 2020) and is not fully understood yet. Up to now, there exist only very few studies, that actually compare rock properties obtained on reservoir core samples with stratigraphically equivalent formations in outcrops. The increased interest in super-hot or supercritical geothermal reservoirs for electricity generation also increased the demand for raw data for numerical modeling and the interpretation of geophysical exploration surveys. Thus a profound understanding of rock properties and how they are affected is essential. As there were no such data available for the GEMex project, this study was initiated to overcome this knowledge gap and to avoid using generalized data from the literature.
See also the comments above.

Referee 2 – line 641: *""In some cases, intensive hydrothermal alteration prevents a clear identification of the original rock type and correlation to equivalent units in the outcrops" –> Good that you mention this limitation. What percentage of cases?"*

Answer: The identification of about 25% of the reservoir core samples were problematic. These samples are marked as "undefined altered lava" in the database. We added this information to line 641.

Comment on figures:

Referee 2 – Figure 3: *"Electrical resistivity measurements are not part of the workflow figure. Why?"*

Answer: Figure 3 represents the schematic workflow of the sample preparation and measurement procedure at TU Darmstadt. Unfortunately, it was not possible to perform electricity measurements at this stage of the project at TU Darmstadt. As described in section 5 "Material and methods" these measurements were performed on selected sample material at GFZ and UNITO. As the majority of the samples and parameters were analyzed at TU Darmstadt, it seemed plausible to us to illustrate the measurement procedure from this institute to demonstrate the general workflow in the laboratory.

Technical corrections:

Comments on technical corrections were carefully read and considered during the review of the manuscript.

Referee 2 – line 602: *""Whenever possible, all parameters were analyzed on each plug allowing the identification of statistical and causal relationships between the parameters improving the accuracy of geostatistical predictions" –> this is hard to follow, maybe split the sentence?"*

Answer: Agreed. We split up the sentence and changed it to "Whenever possible, all parameters were analyzed on each plug. This approach allows the identification of statistical and causal relationships between the parameters and thus, improves the accuracy of geostatistical predictions."

Referee 2 – line 644: *"Current studies including detailed petrographic analyses and ICP-MS measurements, aiming to provide a better description and sample classification (Weydt et al., 2020, in prep.)"*

Answer: We changed the sentence as followed: "Current studies on the reservoir core samples including detailed petrographic analyses and ICP-MS measurements aim to provide a better sample description and classification."

Referee 2 – line 657: *"which concept?"*

Answer: This sentence refers to the statement that "data from the exhumed system in Las Minas can be used as an analogue for modelling the Acoculco geothermal system" in the sentence before. No changes are needed here.

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