Reply on RC1
Samuel Warren Scott et al.


We thank the reviewers for their detailed and helpful suggestions on the manuscript, which led to significant revisions in the manuscript. Most notably, both reviewers requested that in addition to describing the methods used to acquire the data, we present the data in the form of a Results section. While we were initially hesitant during submission to include too much presentation and discussion the data, because it significantly broadens the scope of the manuscript, in response to the comment from both reviewers, a results and discussion section has been added to the manuscript. As this section consists of 1 additional table, 6 additional figures, and 8 pages of text, it significantly lengthens the manuscript.

Below we address the reviews point-by-point, with the original comments posted in grey and the responses in italic.

Comments from Reviewer 1:

The above-mentioned article describes the compilation of petrophysical, mineralogical and chemical properties of Icelandic rocks that have been analyzed over the past five decades. The paper describes the different measurement methods in greater detail. The database is presented in an EXCEL file and comprises five worksheets: 1) Petrophysical properties, 2) Mineralogical and geochemical data, 3) Photographs and sample sites, 4) Additional hyaloclastite data and 5) Extended references. Thereby, the photographs of the samples and sample locations are provided in an external zip file. In general, the article is well-written and clearly structured. However, several aspects should be considered prior publication in Earth System Science Data. Further comments below.

General comments regarding the manuscript:

The database presented here represents an updated version of an already published database available under Orkustofnun (2018; unfortunately, the provided link didn’t work), which mainly contains porosity and permeability data analyzed on 529 samples. The dataset has been expanded in this manuscript by adding data from 302 samples collected by Orkustofnun between 1970-1980, and data from 161 samples retrieved from literature. Data analyzed on 34 samples are actually new and have not been published before.

The structure of the database is adapted from the P³ PetroPhysical Property database by
Bär et al. (2020), which has been published here in ESSD. Some data has been even retrieved from this database; but not all data related to Iceland that is available in this repository were included. In the past two more rock property databases have been published here in ESSD:


The input of the data is similar to Weydt et al. (2021), where in contrast to Bär et al. (2020) the data are stored in one row for each sample.

Two major point of criticism can be derived from this:

- What is actually new about this database? The authors should explain why it is necessary to have an extra database just for Icelandic rocks, also considering the impact factor of this Journal and that the data included in this manuscript has already been published and discussed elsewhere.

While it is true that the layout and contents of the P³ PetroPhysical Property database (Bär et al., 2020) served as an inspiration for layout and contents of the database (in particular the structure of the Excel file), we would like to clarify that we did not “retrieve” any data in our database from Bär et al. (2020). The data in question is most of the samples from the report of Gudmundsson et al (1995) and Franzson et al. (2011). In our database, the data for these samples was retrieved from the original Valgarður database (an Access database – link provided in manuscript is correct), as well as the primary sources (reports written in Icelandic). In addition to petrophysical data for these samples, which is provided in Bär et al. (2020), the present database also contains detailed location and rock descriptions (provided in English and Icelandic), point counting, bulk-rock geochemical data, as well as acoustic velocities and mechanical properties (for measured samples), all which was missing from Bär et al. (2020).

With regards to the question of what is “new” about the database, we refer the reviewer to Table 1, as we added many additional sources of data other than Gudmundsson et al. (1995) and Franzson et al. (2011) to the database and made it easily accessible in one place. While it is true that much of this data has been previously published in the form of figures, this is the first time that this data has been rendered in this form, readily usable for scientists as well as the generic public. This database goes beyond the existing publications and conference papers that have cited this data but have mostly not provided it in tabulated form, let alone as a downloadable file.

We believe that the database serves as a useful stand-alone reference for Iceland, which is a country of tremendous geologic interest due to the active volcanism and widespread use of geothermal energy. Regarding the reviewer’s comment questioning the need for an Iceland-specific database, they cite two previous databases published in ESSD that are highly localized -- one comprising two geothermal fields in Mexico and another for the mid-German Rise. We believe that ESSD is the proper venue for this database.

Although the authors mention the usage of the P³ database as a template in the acknowledgements, it is not mentioned in the manuscript. In my opinion it is necessary to put the development of this database in the right context and to correctly cite the source material as well as other important databases related to rock properties and geochemical data (e.g., Gard et al., 2019).

As discussed above, we do not believe that it is fair to say that we failed to cite the source material, as Bär et al. (2020) did not constitute a source of data. We cite all of the source material in Table 1, as well as in the main database.

We did in fact cite the P³ PetroPhysical Property database in the first paragraph of the introduction but incorrectly cited the year – we wrote Bär et al. (2019), and in the new version this has been correctly cited as Bär et al. (2020). Our sincere apologies for that mistake. In order to better contextualize this database, we added the following sentence to the introduction on lines 35-48:

In recent years, a growing number of databases providing detailed petrophysical (Bär et al., 2020; Weinert et al. 2021; Weydt et al., 2021; Heap and Violay, 2021) and geochemical (Gard et al., 2019; Cole et al., 2022; Harðardóttir et al., 2022) data have been published.


Further points of criticism are:

- The lack of thermal properties and the small number of mechanical parameters. Especially the mechanical parameters would be important for models regarding volcanic activities/eruption/ flank stability as described in the introduction. Furthermore, Iceland
is well-known for their geothermal fields. Thermal properties would be beneficial for, e.g., accurate temperature models.

More mechanical data was added to the database (Arngrímsson and Gunnarsson, 1999). In the new version of the manuscript, we describe how this data was collected in more detail, and present the mechanical data in Figures 14 and 15. With regards to thermal properties, we added thermal conductivity data for ~50 samples in the database, most of which derive from a single lava flow in the Reykjavik area (Guðlaugsson, 2000). We added further discussion of the point on lines 685-690:

Thermal conductivity measurements are only available for a relatively small number of samples, most of which were derived from a single lava flow in the Reykjavik area (Guðlaugsson, 2000). Other studies have measured the thermal properties of Icelandic rocks (Ruether, 2011), and thermal conductivity and thermal diffusivity was measured on a large number of samples obtained from a nearly 2 km long core the Reyðarfjörður region (Oxburgh and Agrell, 1982; Drury, 1985; Flovenz and Saemundsson, 1993). However, to the authors best knowledge, the data obtained in these studies does not exist in tabulated form, at least accessible over the internet.

However, we would also like to note that thermal conductivity varies over a relatively narrow range (1.5-2.5 W m\(^{-1}\) K\(^{-1}\)), which pales in comparison to the more than 1 order of magnitude variation in porosity and ~8 order of magnitude variation in permeability. Since heat transport in high-enthalpy volcanic geothermal fields is generally controlled by fluid advection rather than thermal conduction (e.g., Ingebritsen et al., 2006), the thermal conductivity is of second-order importance in comparison to permeability when calculating the subsurface temperature distribution in high-enthalpy geothermal areas using numerical simulation packages such as TOUGH2. However, the data is more important when modeling conductive heat fluxes outside of volcanically-active areas (Flovenz and Saemundsson, 1993).


The database represents a compilation of datasets obtained over five decades. Thus, different measurement devices and methods have been used on different sample sets. How can you ensure the comparability and reproducibility of the results? Would a data quality control system be useful?

In the paper, we describe in some detail the different measurement types and possible sources of bias related to different methodologies (e.g., Fig. 4). In the revised version of the text, we further developed these points and discussed sources of error with regards to connected porosity measurements on lines 244-258:

Connected porosities measured using gas expansion and triple weighing methods yield similar results, at least within a margin of uncertainty of <2-5%. This is demonstrated in Figure 3a, which reports connected porosity data collected by both methods on core samples from Krafla (Lévy et al., 2018, 2020b). For gas expansion measurements, an additional source of uncertainty is related to the choice of the saturating gas. Figure 3b compares connected porosity measurements performed on a set of hyaloclastite samples using either He (Franzson et al., 2011) or air (Frolova et al., 2005) as the saturating gas, and shows that connected porosity of samples measured using air is lower, likely due to the lesser ability of air to penetrate the microporosity or due to adsorption of water contained in the air into the clay-rich, altered rock. An additional source of error is that helium (or air) pycnometry requires the sample dimensions, whereas the triple-weight method only uses measurements of weight. As laboratory measurements of weight are often more accurate than measurements of length, this is one advantage of the triple-weight method over helium pycnometry. However, repeat measurements of connected porosity on different core plugs obtained from a given rock outcrop (e.g. Fig. 1d) reveal natural uncertainty in the sampled rock of 5-10% (i.e. porosity can range from 5-15% for a given lava flow). Particularly for rocks such as hyaloclastites or flow-top breccias, which show strong gradients in petrophysical properties over distances <1 m, thus the uncertainty resulting from different measurement devices and methods is likely less than the natural variability present in the rock.

We believe that a data quality control system would require subjective judgments about the quality of the data that might not be very well grounded. Instead, we provide detailed information the measurement types used to analyze each type of petrophysical in a column accompanying each data point. Users of the database can use this information to assess whether samples should be included or excluded in their analyses.


Most of the properties have been analyzed on different sample sets. Thus, it is not possible to derive parameter relationships from this dataset, which in turn is crucial for
reservoir parametrization (e.g., THCM modeling) and stochastic models as claimed in the conclusions. I agree that having some data is better than no data, but in the end this fact limits reservoir property estimations significantly. The authors should address this in a chapter regarding the limitations of this database and better explain the usage of the data.

We strongly disagree that “it is not possible to derive parameter relationships from this dataset”. For example, Table 4 clarifies effective porosity and intrinsic permeability have been jointly analyzed on ~500 samples, nearly half of the database. The parametric relationship between porosity and permeability is of crucial importance for THMC modeling. To better clarify the ability of the database to illuminate the relationships between different petrophysical properties, lithologies and alteration zones, in the new version of the manuscript we have added a results/discussion section that presents the data in some detail.

- The paper includes a few figures that contain measurement results. Since the database does not contain too many datapoints (~5000 data points in total based on Table 4 and additional rock mechanical data), it could be beneficial to include a results section and to actually represent the data in greater detail. The authors could discuss the results as a kind of review. Thus, they would provide something new compared to the first version of the Valgardur database.

During initial preparation of the manuscript, we felt that full presentation of the data and discussion of the implications for understanding the relationships between lithology, alteration, and petrophysical properties was beyond the scope of the manuscript. As both reviewer 1 and reviewer 2 commented that it would be good to represent the detail in more detail, we have added a section to the manuscript that presents the petrophysical data in some detail. This significantly lengthens the manuscript. However, full description of the petrophysical, mineralogical and geochemical data is beyond the scope of this manuscript.

- The results of the VS measurements in Fig. 8 show a high scatter. The authors should check this data for outliers and maybe plot also VP vs VS.

We believe that the scatter in the Vp and Vs measurements is real, related to variability in the nature of porosity (e.g. pore vs. microcrack-dominated) and hydrothermal alteration. In the new version of the manuscript, we provided more discussion of sources of variability in these measurements on lines 621-635:

Figure 13a shows that P-wave velocities are typically inversely correlated to porosity: crystalline basalts show the highest velocities and the lowest porosities, while hyaloclastites have the lowest velocities and higher porosities. This relationship has been seen in several previous studies of volcanic rocks (e.g., Pola et al., 2014; Frolova et al., 2014; Wyering et al., 2014; Heap et al., 2015; Durán et al., 2019; Frolova et al., 2021). However, the data show considerable scatter, and the relationship between acoustics velocities measured at dry conditions (shown by transparent markers) and saturated conditions (shown with opaque markers) is complex (e.g., Nur and Simmons, 1969; Kahraman, 2007; Kahraman et al., 2017). Most of the samples show P-waves that tend to travel faster in a water-saturated than dry environment, but several hyaloclastites and lava flows show dry velocities that are systematically ~1-2 km s\(^{-1}\) greater than the saturated velocities. While the P-wave velocity tends to be higher than the S-wave velocity, some hyaloclastites altered to smectite-zeolite conditions tend to show relatively low P-wave velocities. In comparison, hyaloclastites altered to mixed-layer clay or chlorite-epidote conditions generally show higher P- and S-wave velocities. While there is more scatter for S-wave velocities, S-waves show dry velocities that generally exceed saturated velocities by 1-3 km s\(^{-1}\) (Fig. 3b), except for intrusions. However, as P- and S-wave
velocities are strongly dependent on crack density and geometry, low porosity but highly cracked rocks may display in some cases very low velocities at room conditions (e.g., Nur and Simmons, 1969; Vinciguerra et al., 2005; Nara et al., 2011). This is observed for instance in P- and S-wave velocities in low-porosity lava flows and intrusive rocks (Figure 13).

We choose not to plot Vp versus Vs, but rather against connected porosity. While there are many interesting ways to represent the data, in this manuscript we chose to represent it in this familiar format.


- Please improve Fig 1, particularly Fig. 1e.

**We have increased the size of Figure 1 and fixed Fig. 1e.**

- Please be careful with the references. Some articles are cited in the manuscript, but are not included in the reference list and vice versa. Also, the formatting is inconsistent and should be corrected according to the journal’s standards.

**We have gone carefully over the references, and have tried our best to maintain consistency with the ESSD reference formatting.**

Comments regarding the database:

Besides some metadata (references, sample location and descriptions), the first worksheet “Petrophysical properties” contains the results of the different petrophysical measurements. In general, the table is well-structured and the columns are highlighted in different colours to increase the readability. I appreciate the detailed lithological information and the possibility to distinguish between unaltered and altered rocks and to be able to compare this information with the photographs. However, the quality of the sample descriptions varies a lot between the different datasets. Furthermore, the sample IDs are sometimes just numbers (varying from 4 to 150803-03) and in other cases a combination of letters and numbers. It would be useful to use a homogenized sample ID for the database and eventually keep the original ID in a separate column as it has been done in the P³ database in Bår et al. (2020).

**We adapted the suggestion of the reviewer and added an additional column with a homogenized Sample ID, with the identification of the study as well as the original sample number. We note in the text on lines 154 that the different studies provide different levels of detail in the sample descriptions. In the case of many borehole samples, sample descriptions were obtained from well reports.**

The second worksheet “Mineralogical and geochemical data” comprises a comprehensive dataset of major and trace elements, quantitative XRD data and point counting data retrieved from thin section analyses. Likewise, the columns are highlighted in different colours to increase the readability. I appreciate the detailed thin section analysis, which is often missing in other petrophysical datasets. I would suggest to include the rock types here again to make it easier for the user (you don’t need to switch between the sheets). Unfortunately, RRE data is not available here.

**We added the suggestion of the reviewer and added the basic rock types and alteration zones to this worksheet. Note that there is trace element data provided, including several rare earth elements (e.g. Y, Ce, Sc).**

The third sheet only contains the numbers of the photographs and the associated sample IDs. About 140 photos are provided in the additional zip folder. However, as a stand-alone worksheet this looks less impressive. I understand that this database is build according to the P³ database and shall resemble a relational database, but additional information such as lithology and outcrop name would improve this worksheet.

**We adapted the suggestion of the reviewer and added the basic rock types and alteration zones, as sample description, to this worksheet. However, we moved this worksheet out of the main file and added it to a separate file.**
The fourth worksheet includes “Additional hyaloclastite data” and represents a short version of worksheet 1. This table includes a smaller list of rock properties and it is not clear to me why this data is not included in the main data sheet. The different measurement methods as described in line 102 on page 6 could be easily marked in worksheet 1. Furthermore, the list should be edited and be consistent with worksheet 1.

*The main reason this data was included was because measurements of connected porosity using air or He were compared in Fig. 3b. While only the He-porosimetry measurements are reported in the database, as suggested by the reviewer, all the rest of the data has been included in the main data sheet. Therefore, this tab was removed from the database.*

The last worksheet includes the references of the original data sources. However, this could be listed in a PDF file and/or in a much prettier way.

*We adapted the suggestion of the reviewer and removed the list of references into a pdf file uploaded with the most recent version of the repository.*

While there is a "READ ME" sheet at the beginning of the database that contains a brief description of each worksheet, headings and additional information about each table in the various worksheets would improve navigation and orientation in the Excel file.

*We have provided much more detail regarding the contents of each worksheet in the "READ ME” sheet. All necessary information regarding column headings and units is provided in the "READ ME” sheet as well as in each of the main work sheets.*