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Common multilingual database

Title	**Common multilingual database with harmonized datasets**
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Work package	WP4 Transnational Data Management

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Introduction

Harmonized data sets comparable throughout the investigated area are crucial for successful completion of the project. Wide range of geological data can be found in archives of the Geological Surveys of project partners, although these data are diverse and of low uniformity (different formats, scales, projections, origins, units, definitions etc.). Therefore the project application formulated the need to make these datasets available and accessible for scientific work in the Central Europe region. This need is reached through the work package WP4. Common database is not useful only in TRANSENERGY project implementation, but it sets the base for future projects based on joint database and data management.

Establishment of the joint database with harmonized datasets was divided to the time steps described and achieved through various activities under WP4. Following this, tasks were built-up from steps of data acquisition, through design of database architecture and application for project needs:

4.1. Requirements for data delivery – Review of available data based on questionnaire done by all partners

4.1.1. Data summary - Review of available data based on questionnaire done by all partners.

At the beginning of WP4 the inventory of metadata available in partner countries was performed. The process consisted of compilation and distribution of questionnaires, filling in the questionnaires by project partners. Its systematic evaluation is summarized in report "Inventory of metadata available in partner countries"

4.1.2. Database standards - Setting the standards for common database in terms of common units, scales, coordination systems, etc.

Activity followed the outcomes of the 4.1.1. and based the standards for the database (coordinate system, units, scales, etc.). The standards are summarized in report "Database standards".

4.2. Data acquisition and harmonization of existing data

The criteria were to store all relevant geological, hydrogeological, geothermal and other data required to build cross-border geoscientific models. It served as a unification platform, where data from all partner geological surveys having different forms, scales, sources and quality are organized in a common form and stored in one place.

4.2.1. Design of database structure - Design of common database structure based on relevant data

The database architecture was designed after the consultation with the project partners and their experience with databases implemented through other projects. Based on the discussions and common experience the basic structure of the database was described in report 4.2.1. "Common database structure". For convenient installation manual describing steps needed to run TRANSENERGY database on a local PC was distributed to the partners.

The database was designed to perform main tasks: help all project partners loading their data into the database in a convenient way; keep data synchronized across the partners; provide access to all data for purposes of WP5 (cross-border geoscientific models); and supply data to web-based multilingual geothermal resource information tool, which is the task in WP 6.

4.2.2. Harmonized datasets - Filling in the database in the required format under the harmonization “standards” done by all partners

All partners transformed their data in the required format under the harmonization “standards”. Partners responsible for data collection provided data from their own archives, or collected data from public institutes and university sources.

4.3. Evaluation of the harmonized datasets

4.3.1. Evaluation of datasets

After filling in the database, evaluation of the harmonized datasets was done. This included quality check, selection of data used, determination of lack of data and definition of different levels for publicity for the purpose of dissemination of the results. The outcome of this stage was summarized in report “Evaluation of harmonized datasets”.

4.4.1. Investigation results

Based on evaluation of the datasets, requirements for additional investigation and field measurements were set. Proposed additional investigation included field work, such as groundwater sampling and hydraulic tests, laboratory analyses (petrophysical measurements on drilling cores, chemical and isotope analyses and acquisition of additional thermal data. New data obtained by additional investigation are incorporated in the database and will serve for validation and calibration of hydrogeological models (WP5). Results were summarized in report “New data from additional investigations”.

4.5. Finalising and harmonizing database

4.5.1. Common multilingual database with harmonized datasets

Harmonized datasets with additional measurements were divided to 2 levels of publicity: public and expert (used only within the consortium). The content of the database as well as the wells accessible to the public use were chosen after the discussion and agreement of all the partners.

Data on current and potential utilization (reservoir parameters), collected in WP3 were also incorporated.

1. Characterization of the database

The database is organized in two functional parts: back-end database, containing raw data and front-end, serving as a user interface, to which data is linked to. The back-end database is stored at the Oracle database server located at SGUDS, the front-end is represented in the file *Transenergy.mdb*. This has advantages in terms of distinction, interactivity and performance, furthermore maintaining and upgrading the database is easier too, as new versions of the front-end can be deployed independently of the back-end database.

Since data are stored on a centralized server with parallel access of multiple users, no local data is kept at client's side (Figure 1.1). Thus all project partners work with data that is always up-to date. Maintaining the application (adding new functionalities, removing bugs, etc.) is done by issuing new versions of the *mdb* file and distributing it through project's FTP.

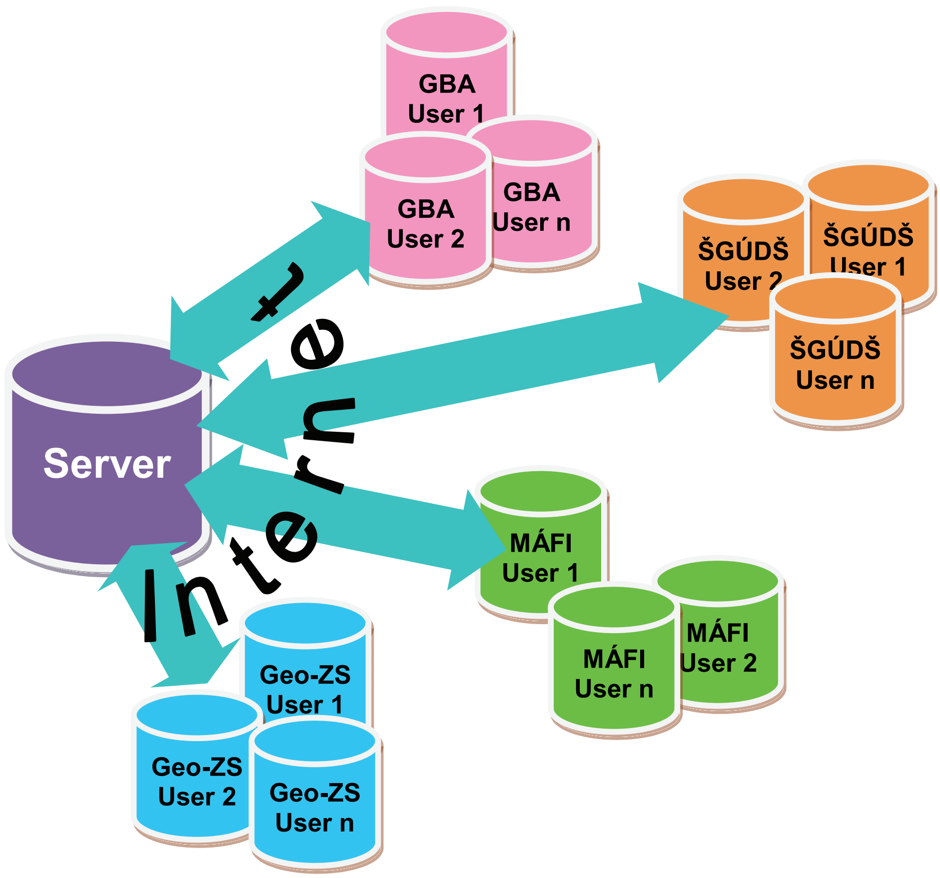


Figure 1.1: Scheme of the TRANSENERGY database connections.

Taking into account technical considerations a decision was made to use Microsoft Access software, which is widely spread, easy to use, customizable and replicable, with data accessible by almost all kind of scientific applications either directly or by RDBMS (ODBC).

Back-end database

The back-end database is a relational database composed of 9 interrelated tables (Figure 1.2).

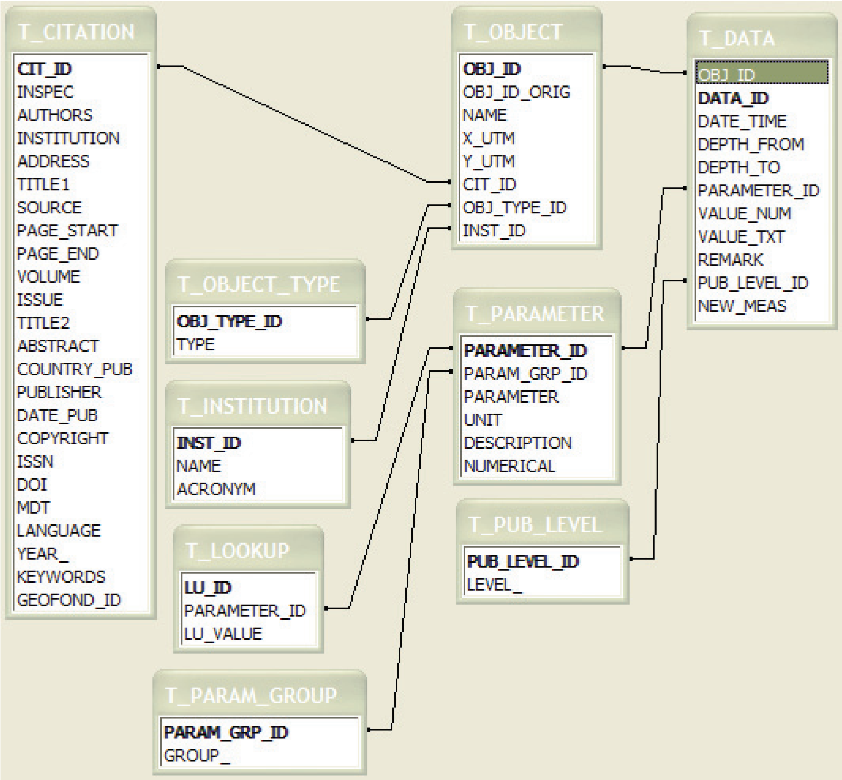


Figure 1.2: Scheme of the TRANSENERGY database data model.

Table *T_OBJECT* is the top level component of the database, to which all other tables are linked. It collects basic identification data about individual geothermal objects, such as boreholes, springs or wells. The source of the information is saved in the *CITATION* field, which is linked to table *T_CITATION*, containing all literature sources used. Data itself is stored in table *T_DATA*, where each record can have either numerical or textual value. Records should be accompanied by date/time and depth interval of the measurement, sample, etc. The nature of data is determined by the parameter, which must be specified in the *T_PARAMETER* table. This table holds all possible kinds of information that can be ascertained at any geothermal object.

Parameters are grouped into logical categories denoting the type of information they belong to. The categories defined, together with examples of data belonging to the each are shown in Figure 1.3.

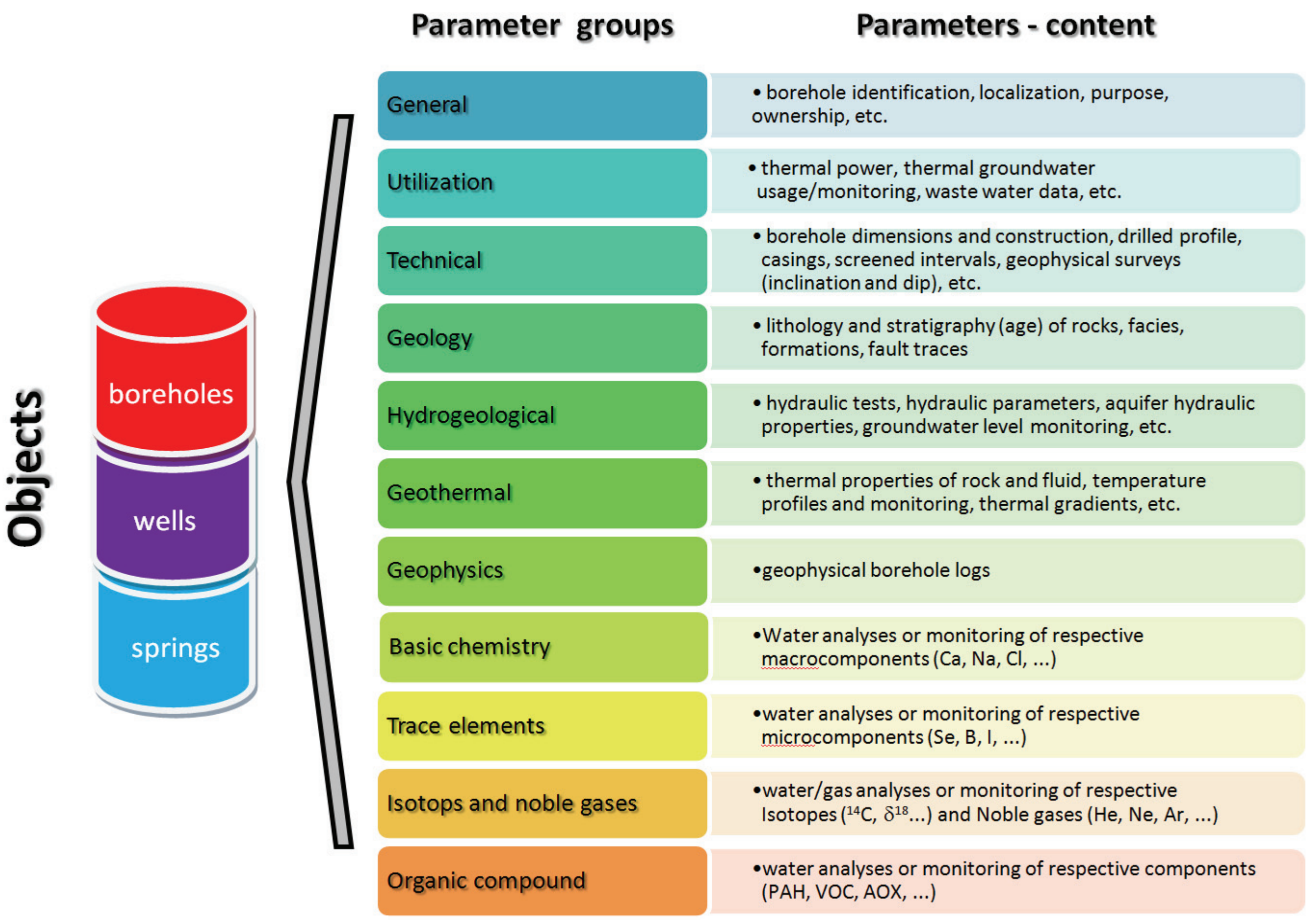


Figure 1.3: Defined parameter groups and their contents

This approach makes additions of new parameters or even whole groups of parameters very easy, thus the database becomes very flexible in terms of content.

Certain parameters can possess only predefined alphanumerical values. For such parameters special coding tables were prepared in which values are locked-up. This concerns citations (table *T_CITATION*), borehole purpose (table *T_PURPOSE*), utilization type *(T_UTIL*).

Front-end

Objective of the front-end application is to provide a user-friendly interface to the underlying data. It does not contain any data in tables, these are dynamically linked from the back-end database. The front-end contains application elements: stored queries, forms and programming. It also allows users to import/link their own data and build custom queries, forms and macros – this feature can be helpful especially when importing data from existing databases. The most important part of the front-end application is the main form, which is described in more detail in the next section.

General functions and procedures

As was written earlier, the interaction with the database is conducted by means of the front-end application, which is launched by opening the *Transenergy.mdb* file. After the start, tables are linked to the back-end database and the main form named *F_OBJECT* opens (Figure 1.4).

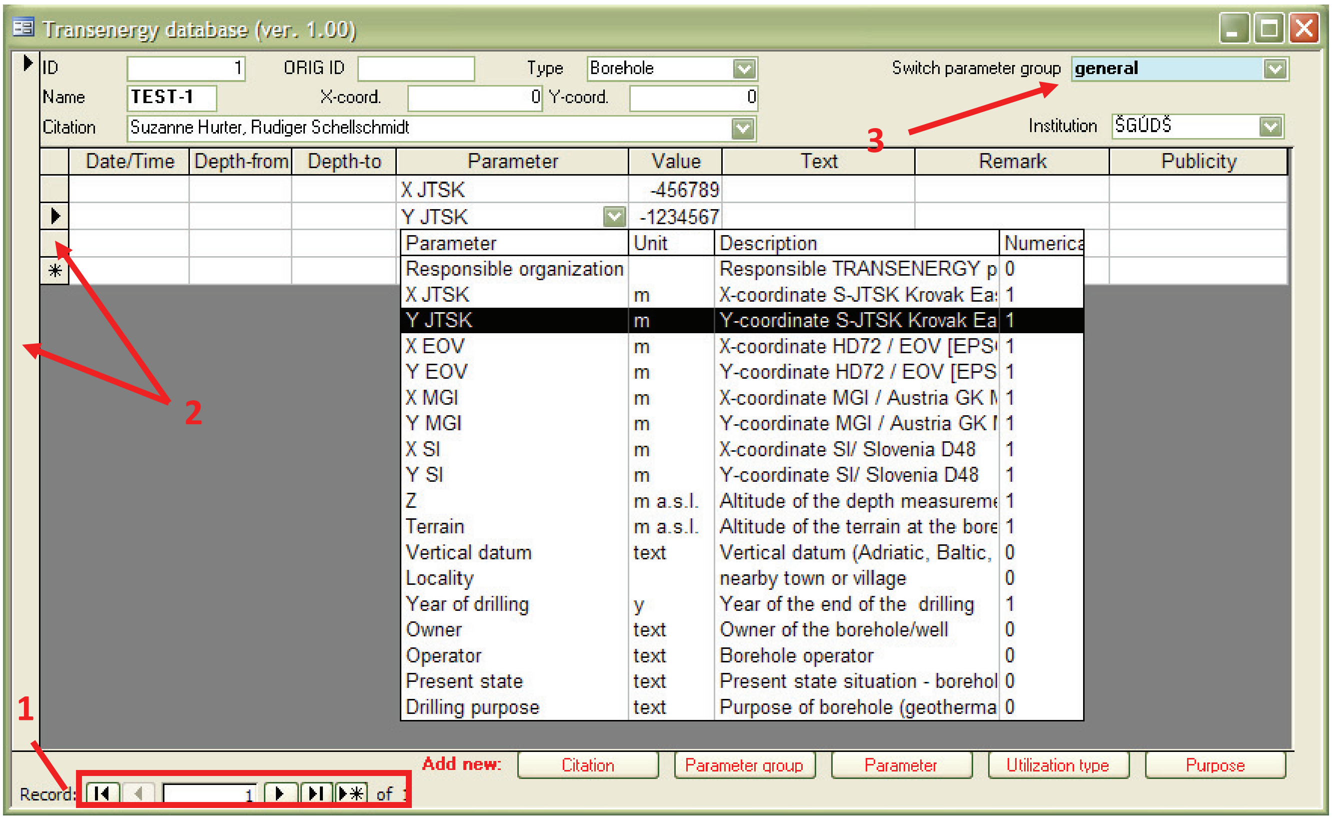


Figure 1.4: Initial display of the main form F_OBJECT.

This form provides a convenient way to view and manipulate all the data stored. At the top of the form are text boxes with basic information related to the geothermal object (borehole or spring). The main part of the form is occupied by a spreadsheet, containing data of a certain category related to the current geothermal object. The content of the spreadsheet changes depending on what category of data is selected in a pull-down list in the top-right (arrow 3 on Figure 1.4), so it always displays only the corresponding subset of data. The categories are specified in the *T_PARAM_GROUP* table. Moving between objects is done with use of record navigation buttons at the bottom of the form (area 1 on Figure 1.4). In order to delete, or copy a record to the clipboard, it must be selected first by clicking on particular record selector – grey area on the left of the form/subform (area 2 on Figure 1.4).

Depending on the data category, either numerical or textual values can be entered. When entering a value that is related to a specific depth and not to a depth interval such as borehole log measurements, the value is written to the field *Depth-to* by convention. Values of numerical parameters must be entered in units defined in the *T_PARAMETER* table, visible when choosing a parameter from the list (Figure 1.5).

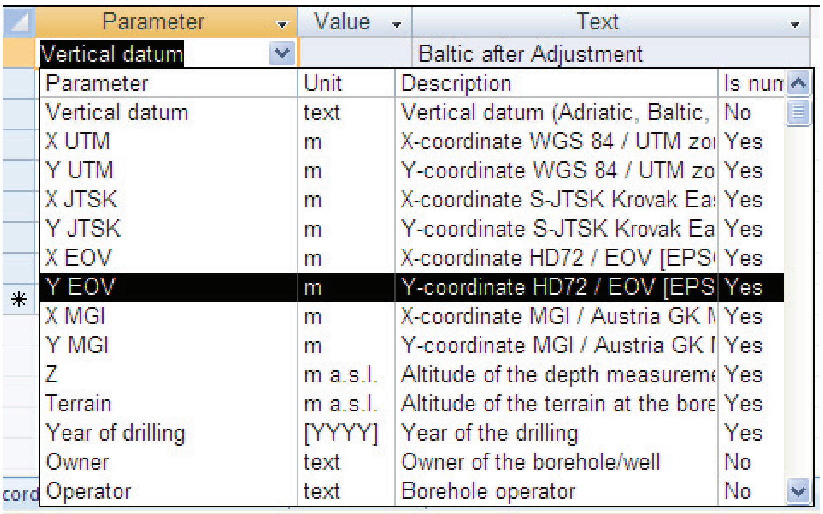


Figure 1.5: Choosing from available parameters

Before a user can choose from one of the predefined values in any part of the main form, it must exist in the corresponding lock-up table. Users can add new parameter, parameter group, citation, borehole purpose and utilization type by adding records in a corresponding lock-up table by pressing the red-labeled buttons at the bottom of the main form. In this case, caution must be paid to avoid duplicate values – users should always check if the parameter doesn't already exist in the corresponding table.

Software requirements

To use the database, same minimum software requirements must be met. It runs under *Microsoft Windows XP, Windows 2000, Windows Vista* or *Windows 7*. Database can be fully operated only with *Microsoft Access 2000* or earlier installed. However, if only viewing forms and adding, editing or deleting data is required, then *Microsoft Office Access 2007 Runtime* can be installed and used. Prior to using the database, an *Oracle instant client* must be installed first – the installation instructions are in the separate file *Installation_Guide.pdf*. It is desirable that users have basic knowledge of Microsoft Access and relational databases in general before starting using the database. Elemental practices on using *Microsoft Access* will not be described in this document, users are recommended to study the software manual first.

Database security and integrity

The database is protected at table level, what means that users can read, insert, update or delete all data in the database depending on the privileges specified for each table. The user TRANSENERGY has granted all privileges necessary for data use (ALTER SESSION, CREATE CLUSTER, CREATE DATABASE LINK, CREATE SEQUENCE, CREATE SESSION, CREATE SYNONYM, CREATE TABLE, CREATE VIEW), but is restricted in changing the database structure. Connection to the database is allowed by providing the correct user name and password, which is assured by the front-end application. Access over internet is restricted by allowing only certain IP addresses.

Concurrent access of data is maintained by record locking model of Oracle server, with conflict resolution implemented by Microsoft Access. The whole dedicated table space is regularly backed-up.

More detail information about the database structure can be find in reoprt „Commom database structure" (Svasta et al., 2010).

Standards for the common database

Datasets in TRANSENERGY database are standardized according all partners agreement and are described in a separate report “Database standards” (Kovacova et al., 2010). Concluded standards are presented in Table 1.1.

Table 1.1: Map data standards.

Character of standard	Standard	Description
GIS (Geographical Information System)	**ESRI shape file (.shp)**	This digital format is set as a standard GIS format to store and exchange Transenergy data.
Coordinate system	**UTM 33 N - (Universal Transverse Mercator coordinate system, Zone 33 – North hemisphere, Datum WGS 84)**	The coordinate system covers study areas of all 4 project countries therefore it is set as a standard coordinate system for Transenergy project. UTM 33 N covers 33U and 33 T zones.
Altitude system (Vertical Datum)	**Local Vertical Datum**	In Transenergy database the altitude of the each borehole or spring is written in the local vertical datum (for example Austria insert altitude in their local altitude system what is Adriatic Vertical Datum, etc...).
DEM – Digital Elevation Model	**SRTM Version 4**	The SRTM Version 4 (newest) was chosen by 3 partner countries as a preference for Digital Elevation Model (DEM) in Transenergy project.
Point data standards (units)	*** Tab 1.2 – units are part of the table**	The units should be used with the point data (boreholes, springs) included in the Transenergy database.

**Tab 1.2: Point data standards (units)*

GENERAL DATA	**UNITS**
X, Y coordinates	UTM 33T
Elevation (elevation of the measured point: top of casing)	metres above sea level
Elevation (elevation of the terrain at the point of the borehole)	metres above sea level
Final depth of borehole	m
Drilled profile: depth, diameter	Depth – metres Diameter - millimetres
Technical profile of well construction (outfit): depth, diameter	Depth – metres Diameter - millimetres
Perforation sections - intervals of perforation from - to	m
True vertical depth (TVD)	m
Measured depth (MD)	m
Dip of borehole	degrees
Azimuth	degrees
GEOLOGICAL DATA	**UNITS**
Faults position - dip, azimuth, depth	Dip, azimuth – degrees; depth - metres
HYDROGEOLOGICAL DATA	**UNITS**
Depth of productive aquifer: top - bottom	m
Effective aquifer thickness	m
Aquifer effective porosity	%
Total porosity	%
Static groundwater level referring to cooled and degassed well in a thermal equilibrium	metres above sea level
Pressure gradient	Pa/m

HYDROGEOLOGICAL DATA (to be continued)	UNITS
Discharge withdrawn by pumping (at the construction phase)	l/s
Discharge withdrawn annual production	m3/year
Groundwater drawdown (by pumping)	m
Hydraulic conductivity K at the local temperature of every tested section	m/s
Absolute (intrinsic) transmissivity of every tested section / aquifer	m3
Transmissivity T of every tested section / aquifer	m2/s
Permeability of every tested section / aquifer	m2
Specific discharge (capacity) of a well	l/s/m
Maximum of exploitable amount of groundwater (maximum allowed)	l/s
GEOTHERMAL DATA	**UNITS**
Temperature profile	depth (m), temperature (℃)
Maximum outflow temperature	℃
Maximum observed temperature at the geothermal structure	°C
Gaslift	Pa
Thermolift	Pa
Temperature in different depths (500 m, 1000 m etc.)	℃
Geothermal gradient (counted to final borehole depth)	°C/km
Mean annual surface temperature	°C
Heat conductivity	(W/m/K)
Specific heat capacity	J/ kg.K
Volumetric heat capacity	J/m3.K
Surface heat flow density	mW/m2
Thermal power of exploitable amount of groundwater	MW
Bulk density	kg/m3
GROUNDWATER PHYSICAL-CHEMICAL DATA	**UNITS**
Volume of dissolved gases	m3/m3
Gas ratio	m3/m3
Gas evasion	m
Dynamic viscosity	Pa/s
Unit weight of water	kg/m3
HYDROGEOCHEMICAL DATA	**UNITS**
Trace elements	μg/l
Isotopes and noble gases	Isotopes ‰; noble gases mg/l, %, TU, Bq/l, ccSTP/g
Chemical analyses of main cations and anions in groundwater	mg/l
Chemical analyses of gases present in groundwater	mg/l
Water mineralization (total and major components)	mg/l
Absolute age determination (isotope) of groundwater	years
GENERAL DATA	**UNITS**
X, Y coordinates	UTM 33T
Elevation at the point of the spring	metres above sea level
Spring water outflow temperature	°C
Spring yield	l/s
Water mineralization	mg/l

2. Evaluation on datasets

This chapter gives an overall look at the data distribution and serves as evaluation of all the records in the database (already with new data from additional investigation). It enables also to consider the data utilization according the projects aims. By the TRANSENERGY project intentions, part of the database will be opened to public. This will be reached through work package WP6 (as an export of relevant data from this WP4 database) and will be published on the project website. Publicity level of the data records from this source (WP4 database) is described in chapter 4 of this document.

Relations between the data present in transnational online database is shown in Figure 2.1.

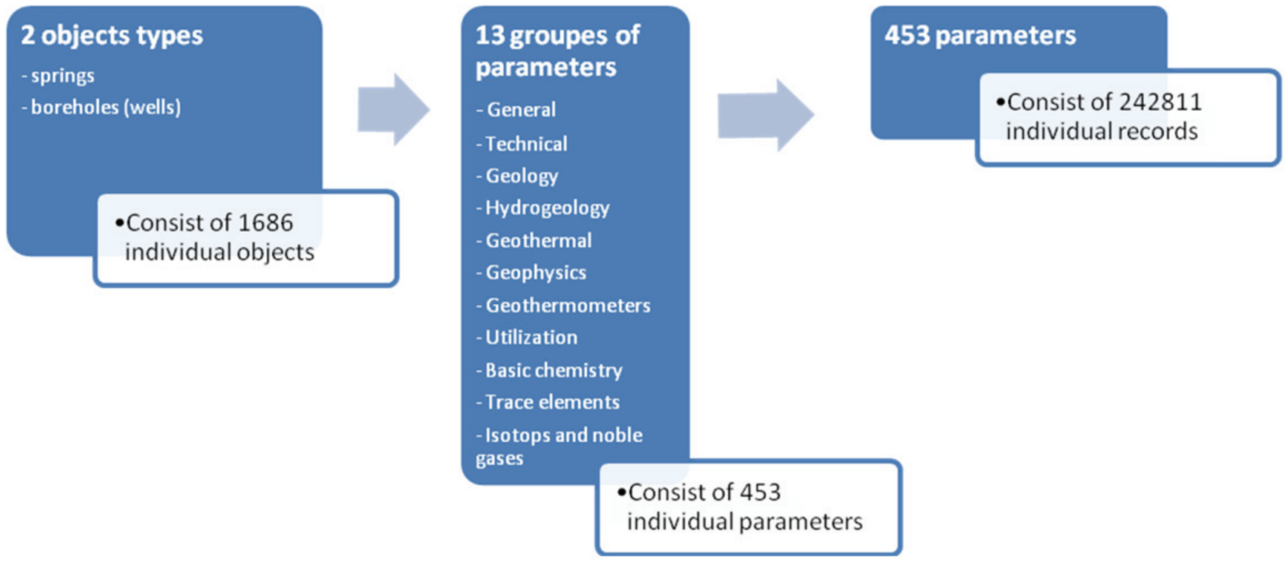


Figure 2.1: Relations between the data present in transnational online database

Principal aim of datasets evaluation in this report was focused on parameters entering geological, hydrogeological and geothermal 3D models. For practical purposes the most adequate parameters were grouped into 6 categories by key parameters (Table 2.1):

Table 2.1: Categories by key parameters used in this report for evaluation of the database

CATEGORIES BY KEY PARAMETERS	SELECTED PARAMETERS	DESCRIPTION
Character of data	all objects with their records	provides a spatial overview of all objects, summarize amount of records according their character
Depth of boreholes	various depths intervals were selected: (< 500 m, 500 – 1000 m, 1000 – 2000 m, 2000 – 3000 m, 4000 m >	it allows to see spatial distribution of boreholes with particular depths

CATEGORIES BY KEY PARAMETERS	SELECTED PARAMETERS	DESCRIPTION
Geological information	all parameters related to group "Geology" (lithology, age, facies, formations, …)	parameters that represent objects (boreholes) with available geological information, important for geological modeling
Hydrogeological information	all parameters related to group "Hydrogeology" (conductivity - k, transmisivity - T, …)	parameters to review available datasets needed for hydrogeological modeling
Geothermal information	all parameters related to group "Geothermal" (geothermal gradient, heat conductivity, specific heat capacity, temperature at final borehole depth or surface heat flow density, …)	respective parameters
Hydrogeochemistry	all parameters related to groups "Basic chemistry", "Trace elements", "Organic compounds", "Gas analysis", "Isotopes and Noble gases" (Na, CO_2, Cu, N, ^{14}C, He, …)	respective parameters

To review the database content and perform the evaluation of datasets we looked at the records from point of view of:

1. Spatial distribution of objects
2. Total numbers of datasets – basic descriptive statistics
3. Vertical distribution of data
4. Specific outputs (new data from additional measurements, "public" database, objects and data characterization, data correction)

Practically, first specific queries in database software (MS Access) were made, next process in spread sheet format (MS Excel) and GIS software (MapInfo).

2.1 Results of evaluated datasets - Character of data

The datasets in the database were obtained mainly from boreholes (wells) drilled for hydrocarbon, geothermal, hydrogeological, or geological – research purposes. Several of objects represent also springs (natural discharge of thermal waters) (Figure 2.1.1).

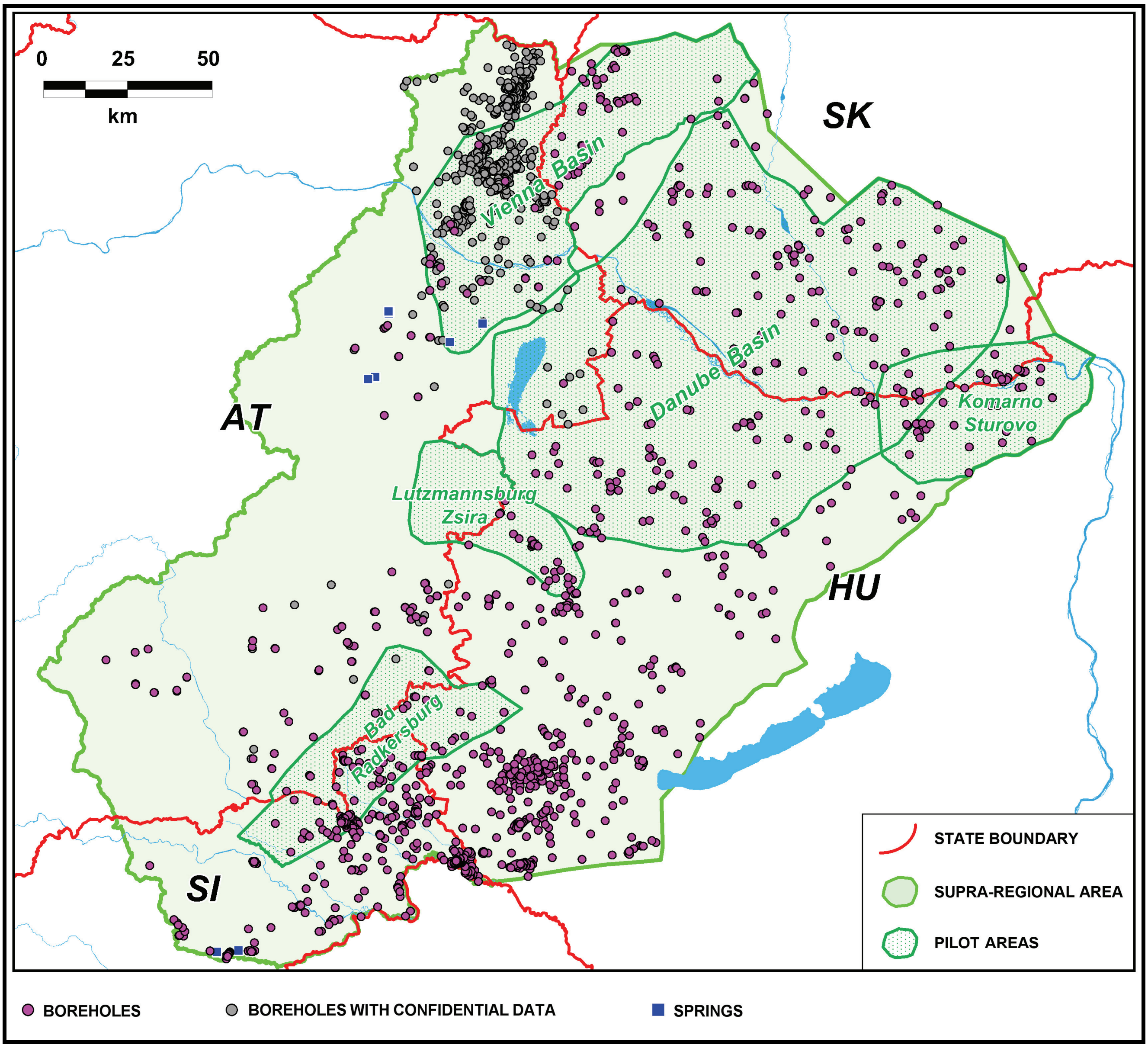


Figure 2.1.1: Spatial distribution of objects

On the western part of the region there is limited borehole data as a result of the mountains – Alps, where few drillings were performed mainly in intra-mountain basins. On the other hand at the mountainous areas (especially western part of the supra-region) not only point data (boreholes and springs incorporated into database) were used, but also relevant maps (geological, hydrogeological) create a good base for planned "geoscientific" modeling.

Most of Austrian data are confidential (by the different regulations, see report on Legislation as an output of WP3, were constrains are described), so only their approximately positions are shown on the map (Figure 2.1.1). The present evaluation in this report shows only public boreholes from Austria which data are incorporated into the database. However all Austrians data will be used in geoscientific modeling as interpreted grid files. Annex of this report provides a summary on Austrian confidential data (Chapter 7).

Objects (including the springs) in TE database consist of many relevant datasets; in total **1686 objects, 242811 records** are incorporated for the entire supra-regional area. Figure 2.1.2 shows all objects and total records distributed within pilot areas.

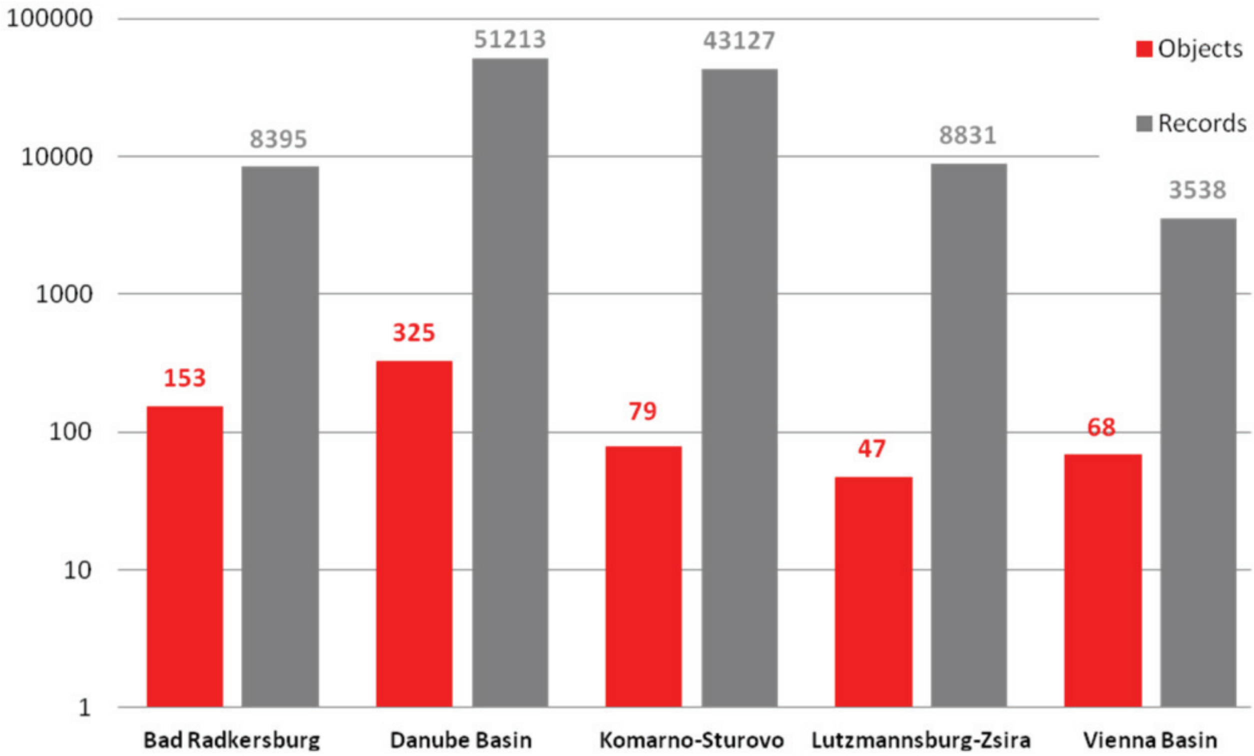


Figure 2.1.2: Amounts of all objects and total records in the pilot areas

Danube basin has significantly higher amount of boreholes and records due to size of the modeled area. Higher amount of records in Komarno-Sturovo block is related to higher amount of hydrogeochemical data entered into database for this specific area (see Chapter 2.6). Confidentiality of Austrian data caused that less objects and records characterize the Vienna basin.

The most abundant amount of records is in category chemical data (basic chemistry, trace elements, isotopes and noble gases, organic compounds and gas analyses) (Figure 2.1.3). Chemical data can often contribute to better understanding of hydrogeological and geothermal models and often serve as supporting data for model result verifications. More detailed information about chemical data in database is presented in chapter 2.6.

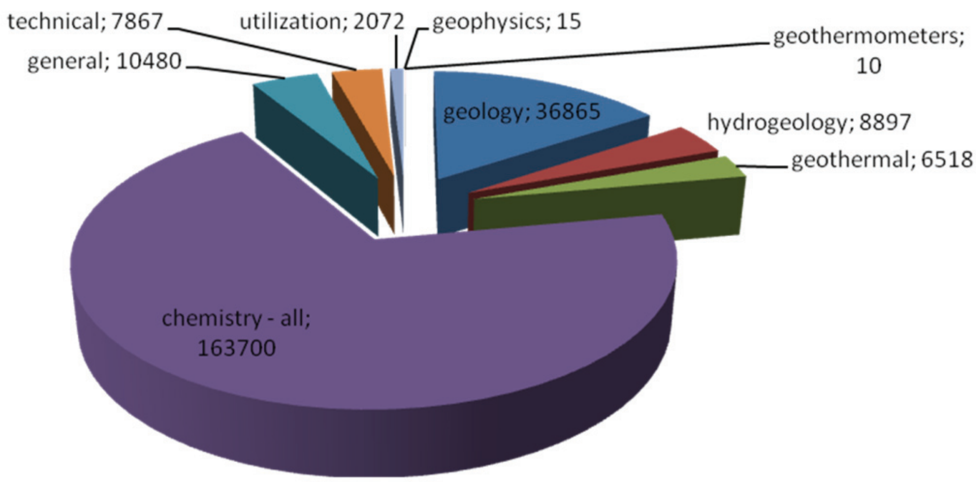


Figure 2.1.3: Proportional abundance of datasets according to selected parameters groups

Data in the parameter groups: “geology”, “hydrogeology” and “geothermal” are used for planned “geoscientific” models – geological, hydrogeological and geothermal models. From the pie chart Figure 2.1.4 it can be seen that in the Supra – regional area geological data are the most abundant

(70 %). Amounts of data in particular data groups correspond to the "geoscientific" model step by step approach, where the geological model is established first which serves the basis for the hydrogeological model, followed by the geothermal model.

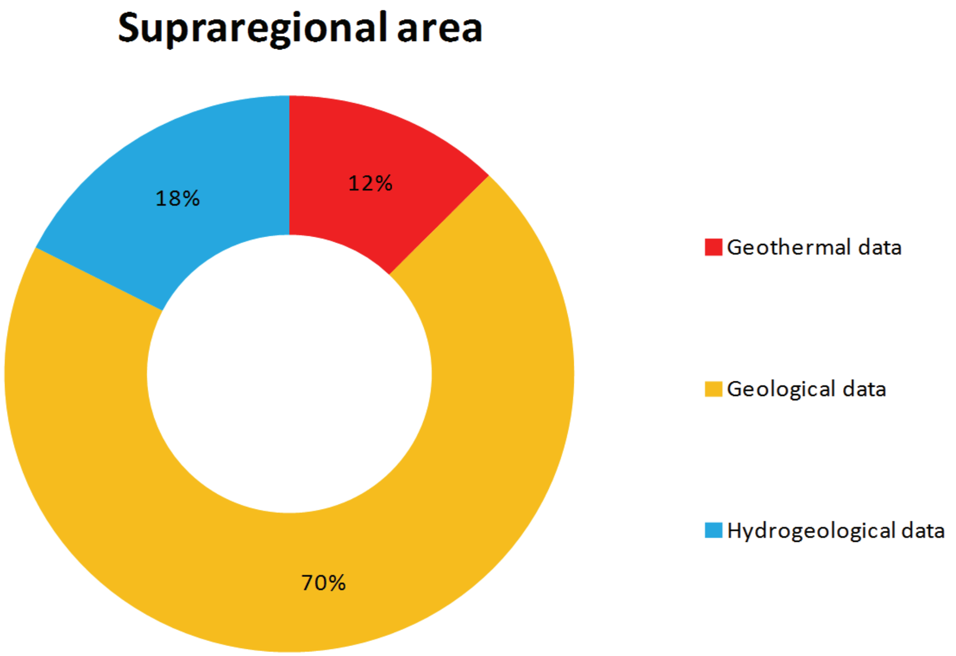


Figure 2.1.4.: Percentual abundance of data according selected parameter groups within Supra-regional area.

2.2 Results of evaluated datasets - Depth of boreholes

Different depths of boreholes could limit the use of datasets related to 3D modeling purposes. From selected depth intervals of boreholes, the TE database contains boreholes mostly from 100 to 500 m depths and from 1000 to 2000 m depths (Figure 2.2.1).

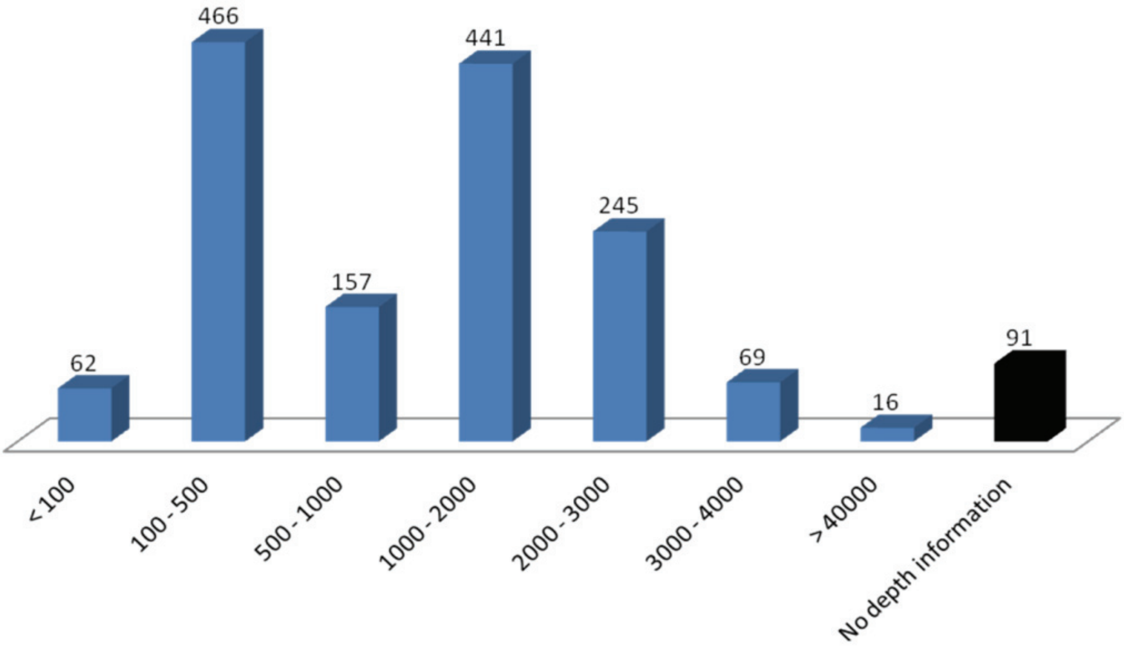


Figure 2.2.1: Numbers of boreholes according selected depth intervals (not including the springs)

Amount of boreholes in particular depth interval is related mostly to geological structure of given pilot area. Deeper boreholes are mostly required for basin geological structures like Danube basin or Mura-Zala basin. On the other hand Komarno-Sturovo block represents lifted Mesozoic structure where geothermal water can be obtained from more shallow aquifers. This is also obvious from spatial distribution of the boreholes according their depths within supra-regional area (Figure 2.2.2).

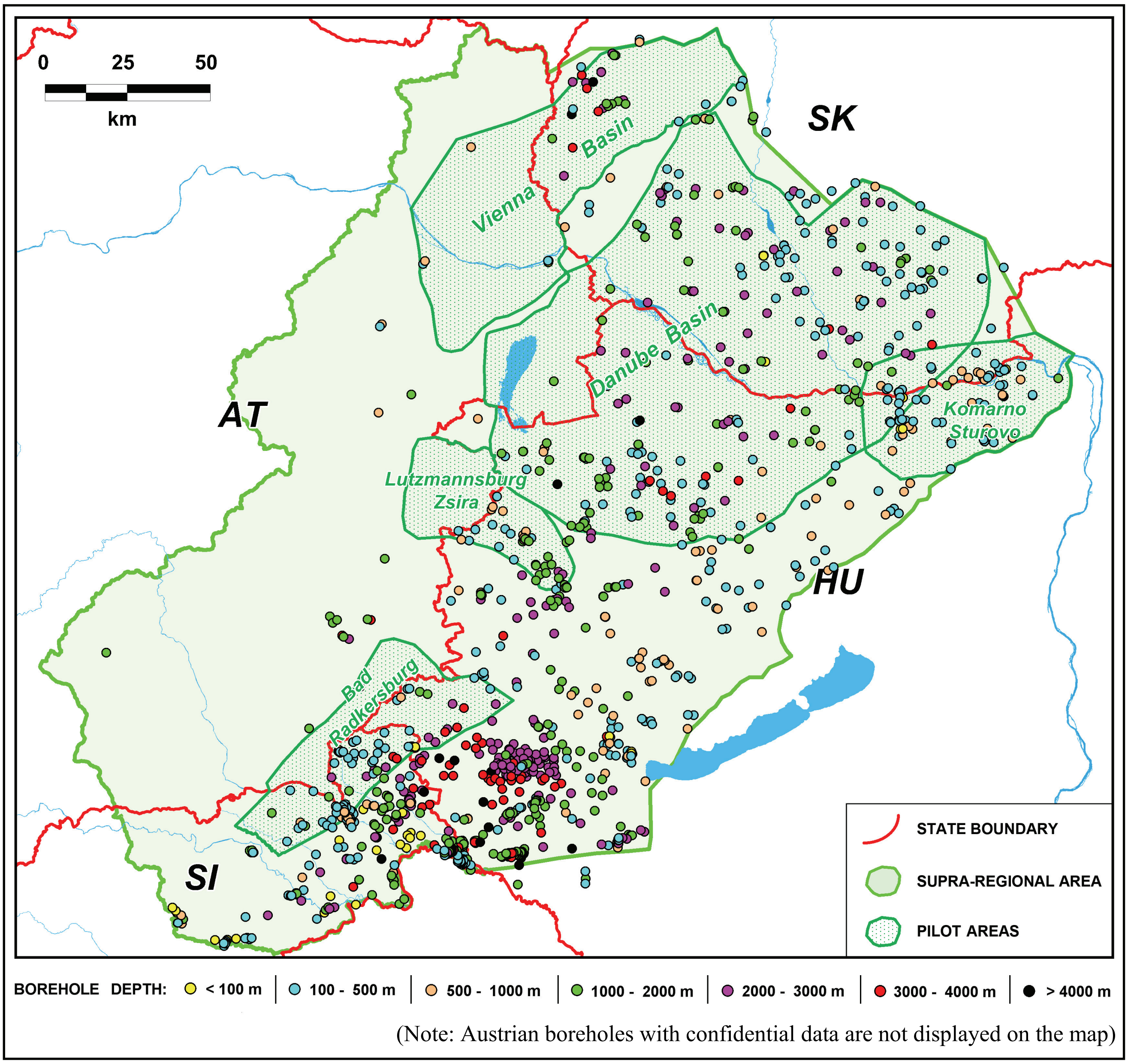


Figure 2.2.2: Spatial distribution of boreholes depth intervals

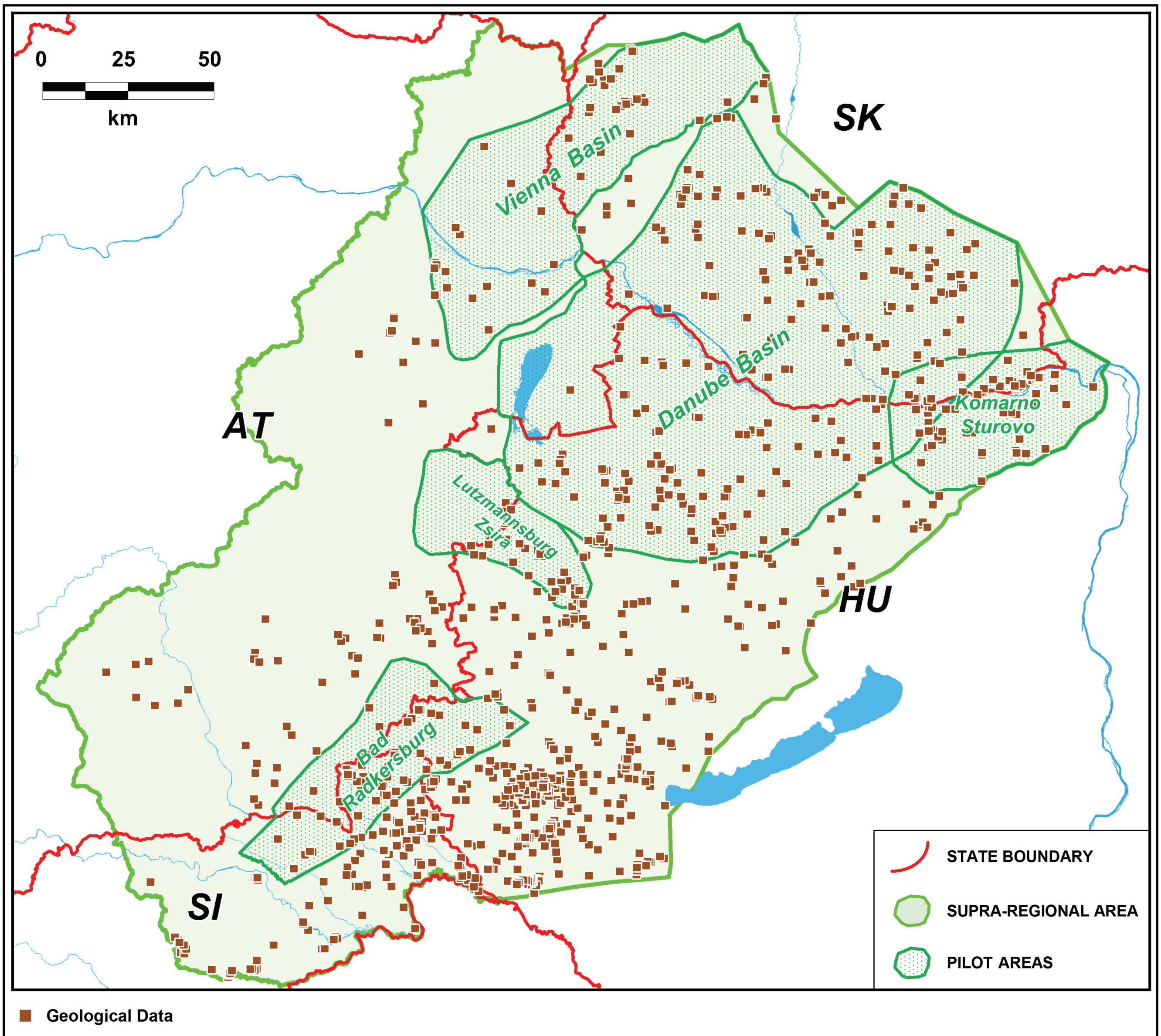
As mentioned earlier, on the western part of the supra-region area some of the source data (that will be used for modeling) come from areal information derived from geological and hydrogeological maps. Point data included in the database (and that are matter of evaluation in this report) play role in the areas of the basins.

2.3 Results of evaluated datasets - Geological data records

Evaluation of geological datasets was focused on availability of geological information for 3D geological modeling. Geological information in database originated from core samples and represent point data source. For the purposes of geological modeling information also from surface geological maps, geological outcrops, published reports and interpretations of geophysical measurements will be used.

Geology has a harmonized legend according to the supra-regional geological model (as a result of the activities under WP5). More detailed description of the harmonized legend can be found in the reports related to WP5 "Geological models".

Geological parameters like lithology, age, facies and formations characterize the subsurface environment related to particular objects (boreholes) at the specific depth intervals. Spatial distribution of boreholes with geological data is presented on Figure 2.3.1.



(Note: Austrian boreholes with confidential data are not displayed on the map)

Figure 2.3.1: Spatial distribution of available geological data

Central part of supra-regional area has an even spatial distribution of geological data. Southern part of the Danube area has more dense net of boreholes content geological information. The western and eastern parts of the supra-regional area are represented by mountain ranges (Alps and Transdanubian Central Range) with limited information form boreholes.

Amount of all geological records related to pilot areas shows proportional occurrence of data compared to the spatial distribution of boreholes (Figure 2.3.2).

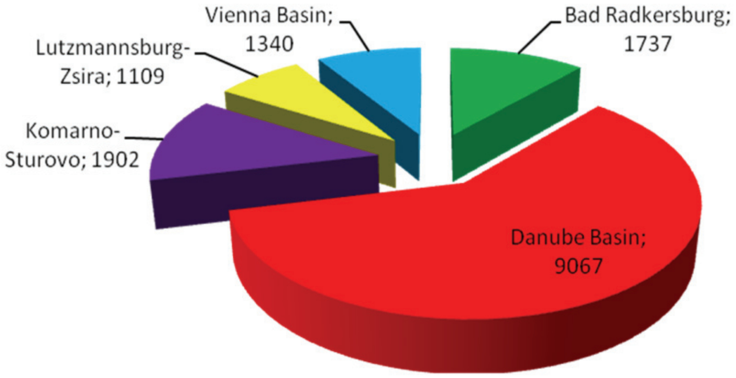


Figure 2.3.2: Amount of geological records related to each pilot area

These data provide information about geological composition of each particular pilot area just from boreholes. Probably in Vienna basin are more boreholes with geological information present but due to their confidentiality the data are not taken into account.

Geological records describing all kind of geological structures are mostly frequented along the first 400 m. With depth the geological records are less frequent. For geological modeling purposes chosen published cross-sections (and accessible seismic profiles) were used especially for deeper structures in central part of the basins (Figure 2.3.3).

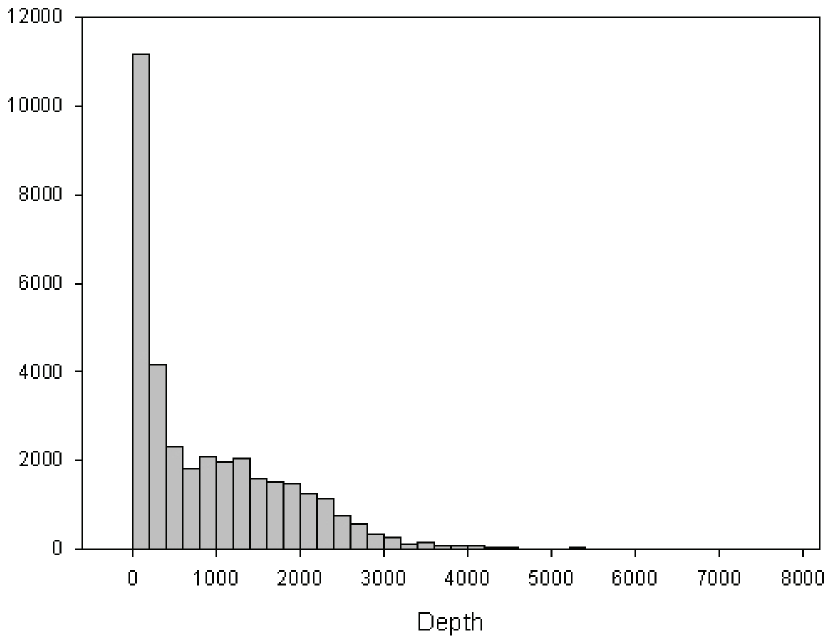


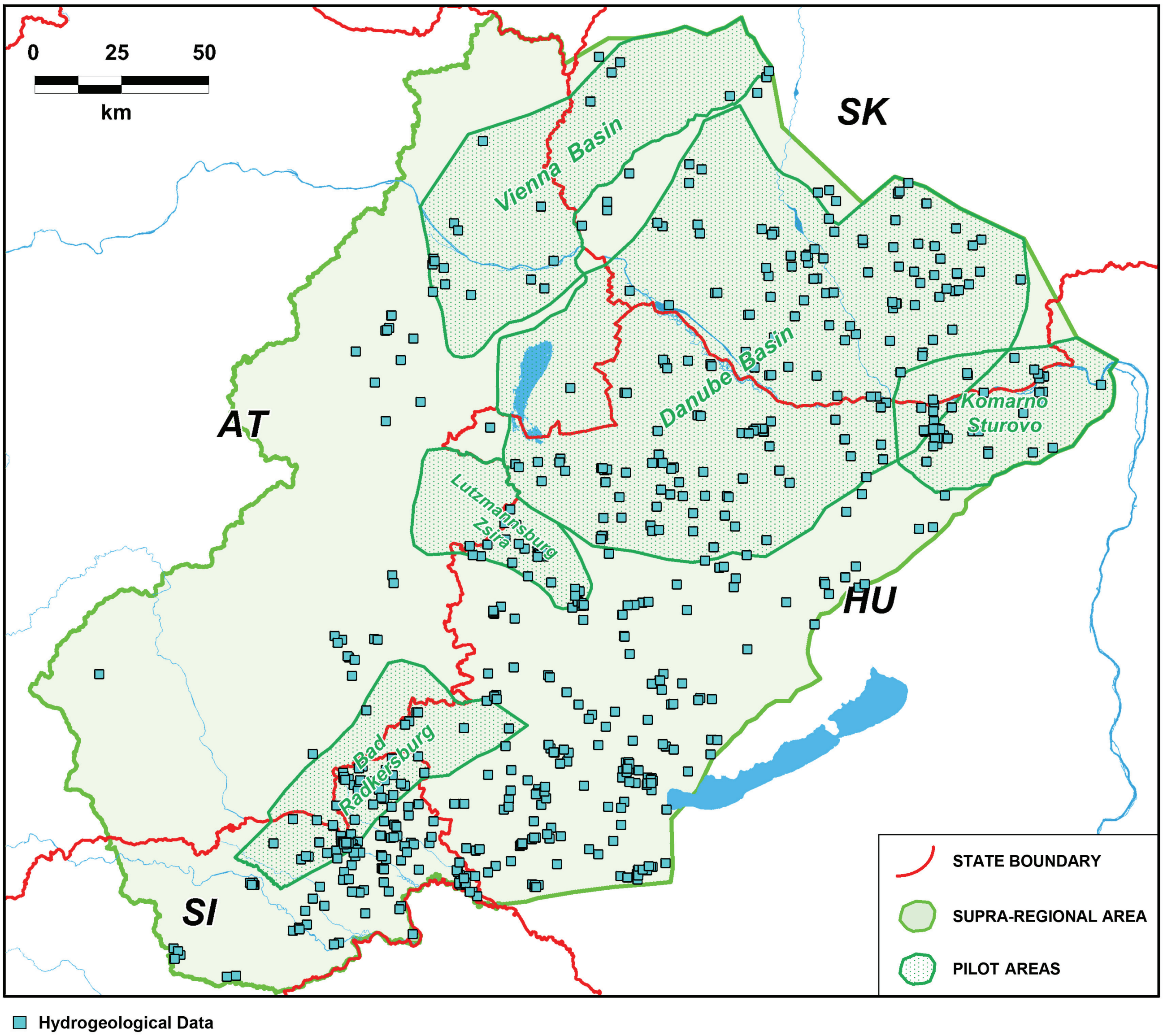
Figure 2.3.3: Number of geological records versus depth

Comparing number of geological records versus depth (*Figure 2.3.3*) with numbers of boreholes according selected depth intervals (*Figure 2.2.1*) no second peak around the depths 1000 – 2000 m is present. Probably this reflects the presence of more reservoirs in these depths (see Chapters 2.4 and 2.5).

2.4 Results of evaluated datasets - Hydrogeological data records

Hydrogeological information is necessary to characterize the subsurface environment for hydrogeological modeling as well their need for further geothermal modeling. Database contain only points source of data represented mostly by hydrogeological boreholes or springs. Boreholes drilled for hydrocarbon investigation, geological research, or geothermal purposes can as well contain some hydrogeological information.

To present spatial distribution of objects containing hydrogeological data objects according 19 reasonable hydrogeological parameters (granulometry horizontal permeability, core vertical permeability, core horizontal permeability, specific discharge (capacity) of a well, coefficient of storativity S, permeability, transmissivity T, hydraulic conductivity K, discharge withdrawn by pumping, dynamic pressure in borehole, dynamic groundwater level, static pressure in borehole, static groundwater level, aquifer porosity type, aquifer total porosity, aquifer effective porosity, aquifer lithostratigraphy, effective aquifer thickness, well yield) were selected (Figure 2.4.1).



(Note: Austrian boreholes with confidential data are not displayed on the map)

Figure 2.4.1: Spatial distribution of available hydrogeological data

Spatial distribution of boreholes with hydrogeological records in basins (excluding mountain regions) of supra-regional area is with even distribution. Smaller amount of boreholes in the western part is related to mountains area (Alps). On the other hand this part of the supra-regional area is represented by higher numbers of springs. Another reason is the confidentiality of Austrian data.

Except presented database, also other hydrogeological information in form of raster or vector information exist (e.g. maps, groundwater table levels). Specific hydrogeological maps will serve as input to the hydraulic modeling (especially Hungarian hydraulic/hydrogeological maps are valuable sources of the data).

Amount of hydrogeological data records within the pilot areas is presented on Figure 2.4.2.

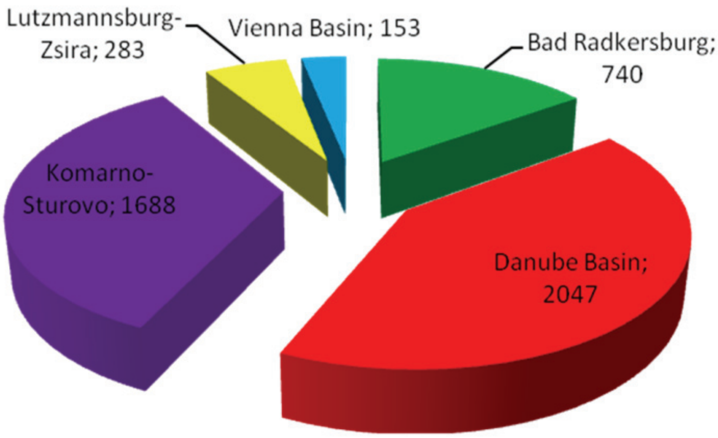


Figure 2.4.2: Amount of hydrogeological data records related to each pilot area

Variability in amount of records according particular hydrogeological parameters is shown on the Figure 2.4.3. Most of the records are characterized by static groundwater level, aquifer porosity type and yield of the well.

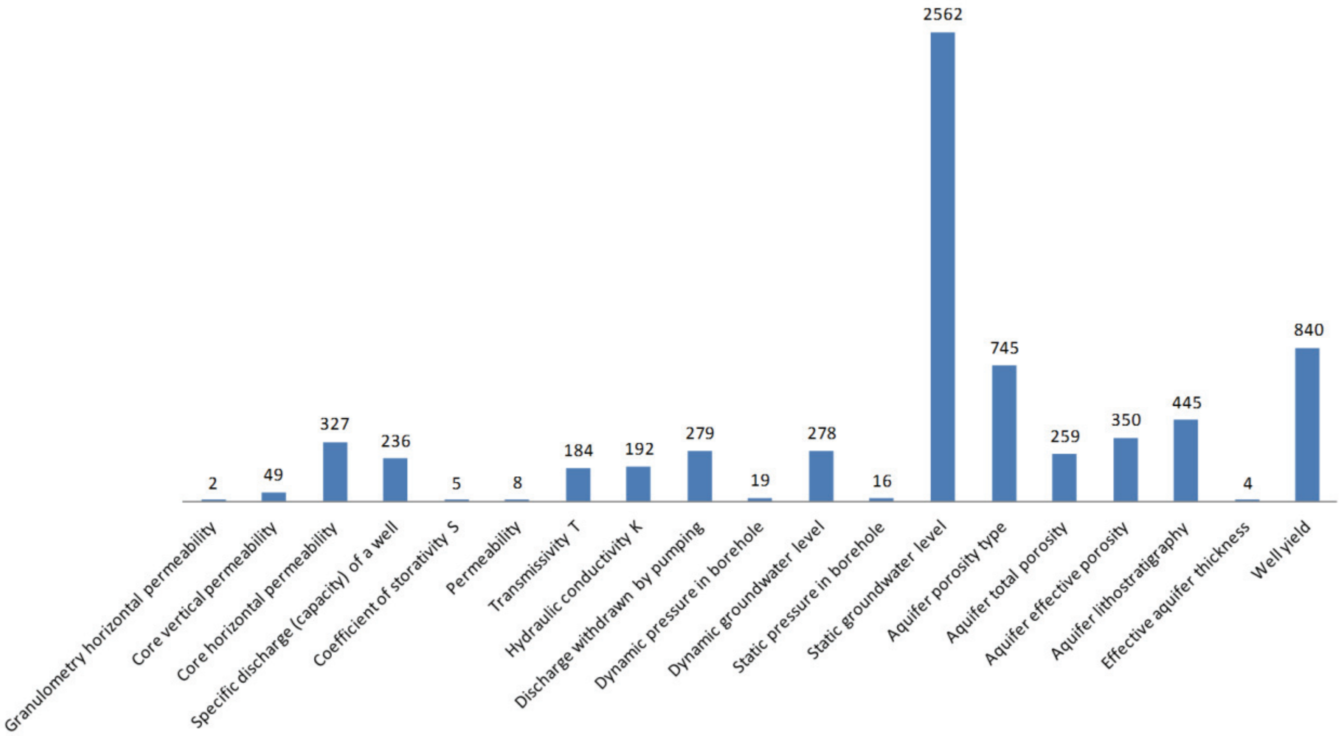


Figure 2.4.3: Count of data records according to selected hydrogeological parameters

The parameters hydraulic conductivity (k) and transmissivity (T) are the most representative parameters for hydrogeological modeling purposes. Even they data records are less frequent they can be substitute by variety of different hydrogeological parameters and their combinations.

The distribution of hydrogeological data along the depth is shown on Figure 2.4.4.

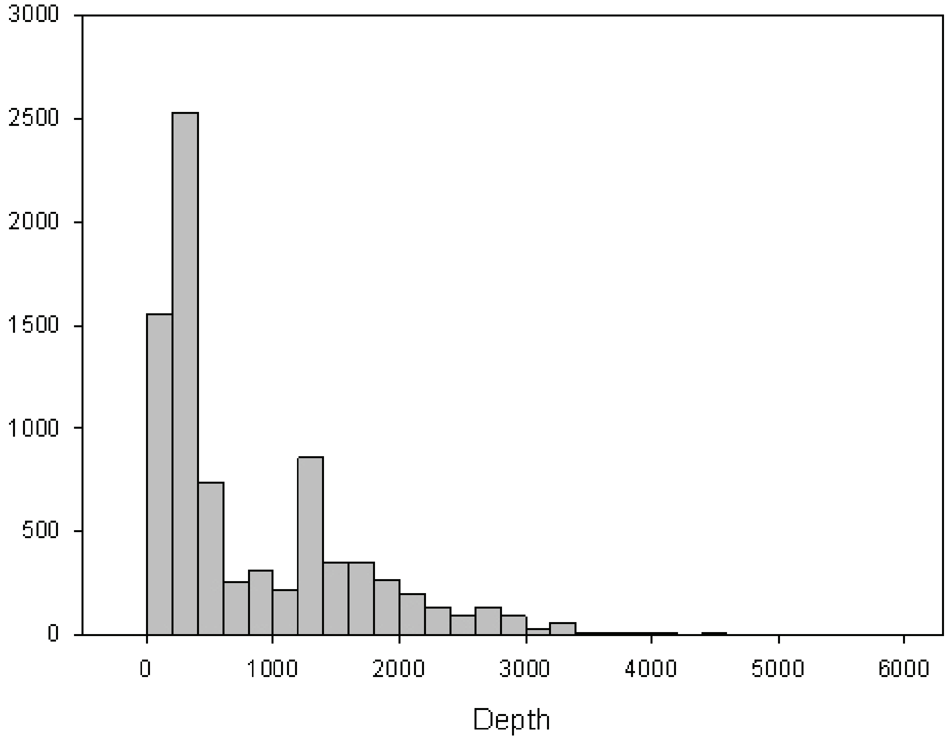


Figure 2.4.4: Numbers of hydrogeological records related to depth

The most frequent records in the database (of any kind of the hydrogeological data) can be found in upper 500 m, originating from the "shallow" hydrogeological wells. Very probably other peak (records between 1200 – 1800 m) shows hydrogeological data originating from geothermal wells.

2.5 Results of evaluated datasets - Geothermal data records

Geothermal information in Transenergy database provides primarily an input for geothermal modeling. Sources of geothermal information are mostly boreholes drilled for geothermal purposes. Important springs are incorporated in the database (this includes mostly temperature, yield and basic chemistry of water). Spatial distribution of objects containing geothermal data records are presented on Figure 2.5.1.

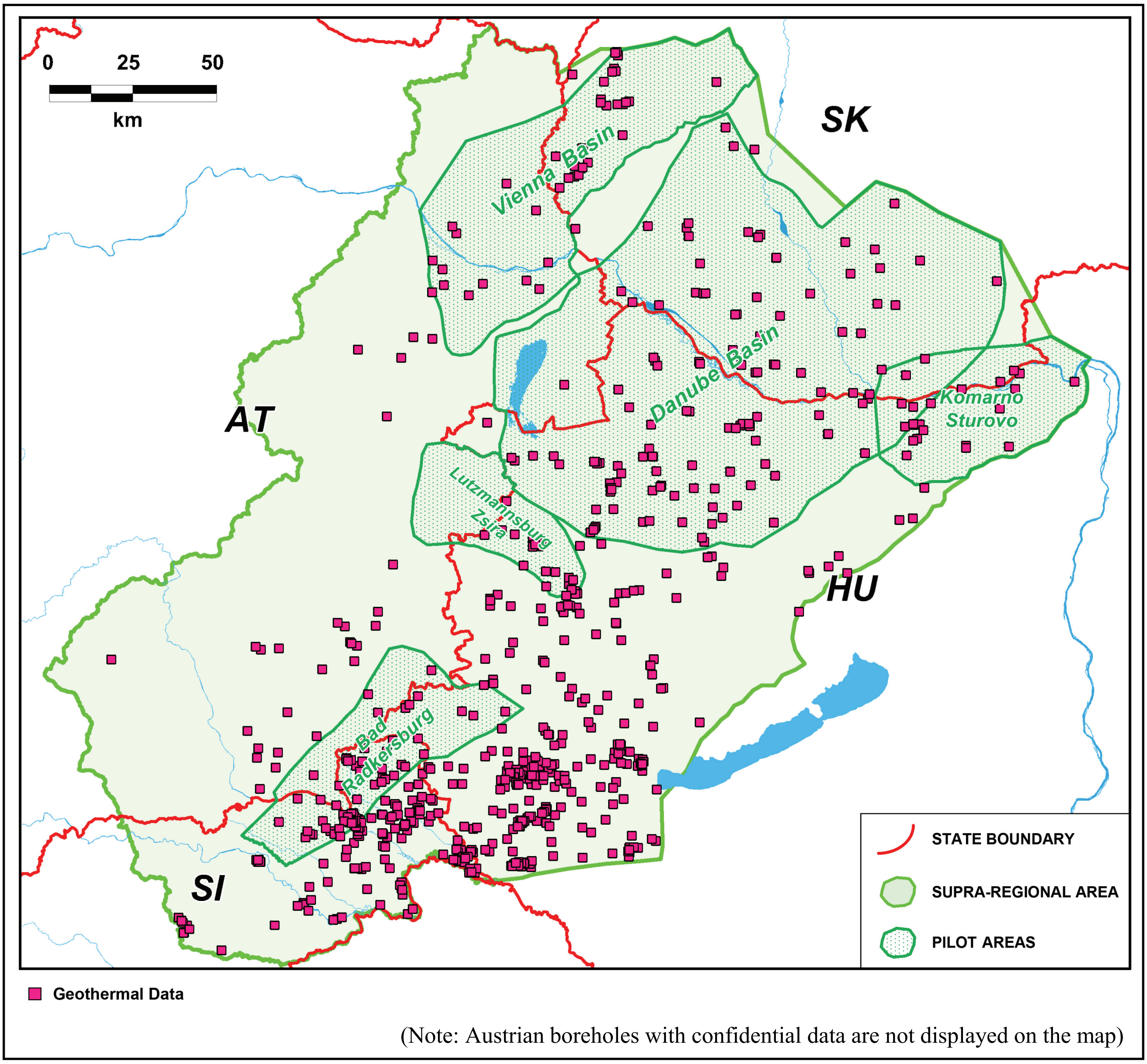


Figure 2.5.1: Spatial distribution of available geothermal data

Supra-regional area is covered by objects with geothermal information relatively well. Distribution of objects is determinated by aims of investigators and character of a particular pilot area.

Distribution of the data records in pilot areas is shown on Figure 2.5.2. Amount of geothermal data according to specific geothermal parameter (bulk density, surface heat flow density, specific heat capacity, heat conductivity, geothermal gradient, temperature at final borehole depth, maximum structure temperature, maximum outflow temperature, static temperature in borehole, dynamic temperature in borehole) is shown on Figure 2.5.3.

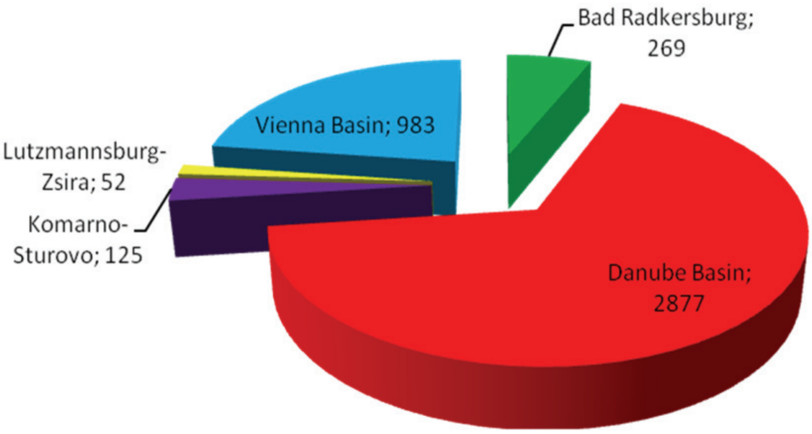


Figure 2.5.2: Amount of geothermal data records related to each pilot area

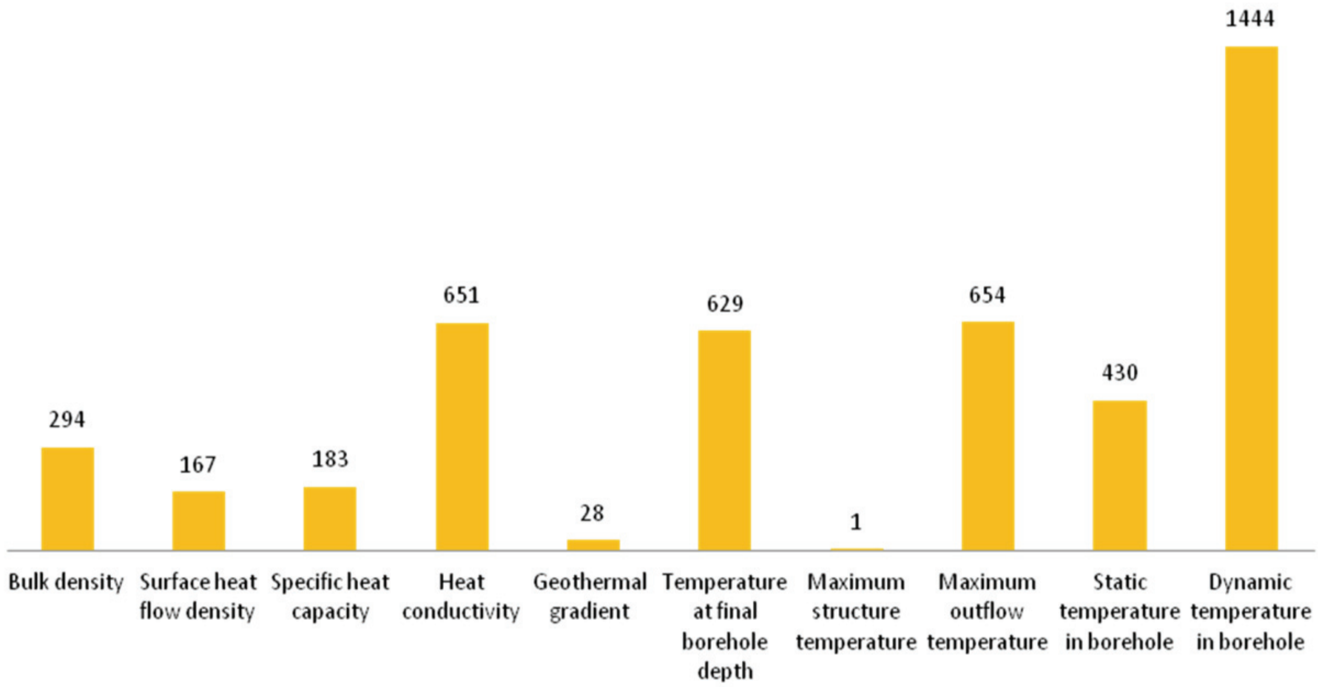


Figure 2.5.3: Distribution of data records according selected geothermal parameters

For geothermal modeling purposes, the most required parameters are "temperature - at final borehole depth", "geothermal gradient - at final borehole depth", "heat conductivity", "specific heat capacity", "surface heat flow density". Each of the project partner uses different kind of parameters for geothermal characterization (e.g. SGUDS-surface heat flow density and heat conductivity, MÁFI – bottom-hole temperature). Variety of different geothermal parameters allows the substitution of some missing data with other relevant parameters.

Distribution of the records (geothermal data) related to different depth intervals is shown on Figure 2.5.4.

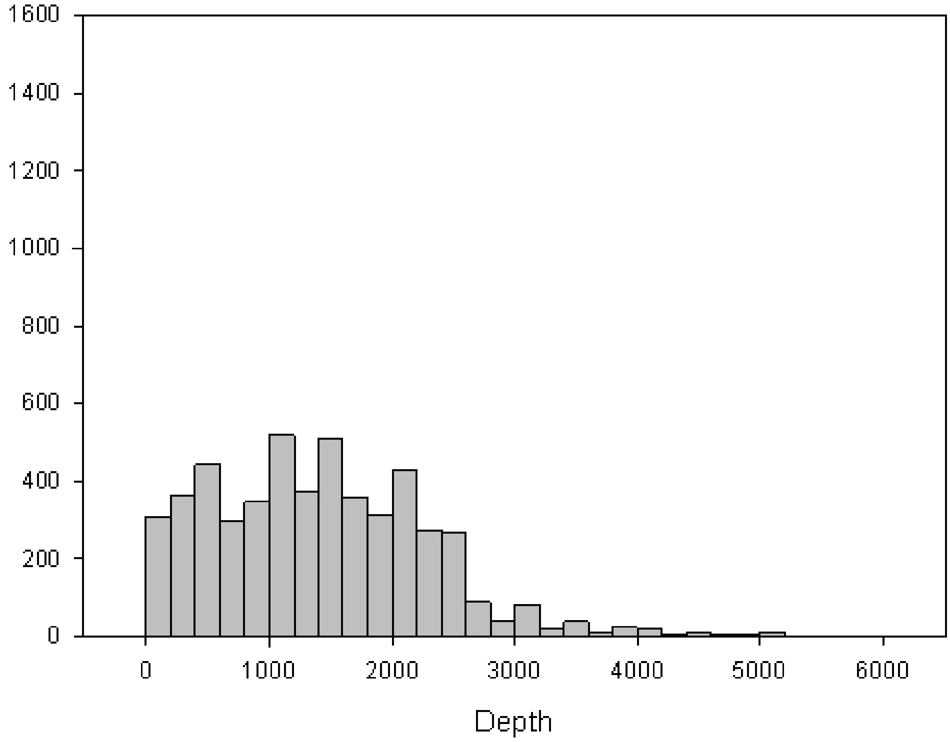


Figure 2.5.4: Number of geothermal records related to depth

Majority of geothermal data is evenly spread along first 2600 m. This corresponds with depths of major geothermal reservoirs.

Again we have to remind that database contains only point data inputs in the database. Part of the data (not used in this statistics) was abstracted from the specific hydrogeological maps, geothermal maps (atlas) and cross-sections and will also serve as inputs to geothermal models.

2.6 Results of evaluated datasets – Hydrogeochemistry data records

Hydrogeochemical data can indirectly add missing information for better understanding of subsurface environment, especially groundwater flow-paths and origin. Hydrogeochemical datasets in TRANSENERGY database are divided into 5 groups of parameters: Basic chemistry, Trace elements, Isotopes and noble gases, Organic compound, Gas analyses. Their spatial distribution can be seen on Figure 2.6.1. Data were obtained by water chemical analysis from all kinds of objects. In many cases water from one object can have more records of the same parameter (different time of the sampling, different depth of the sampling).

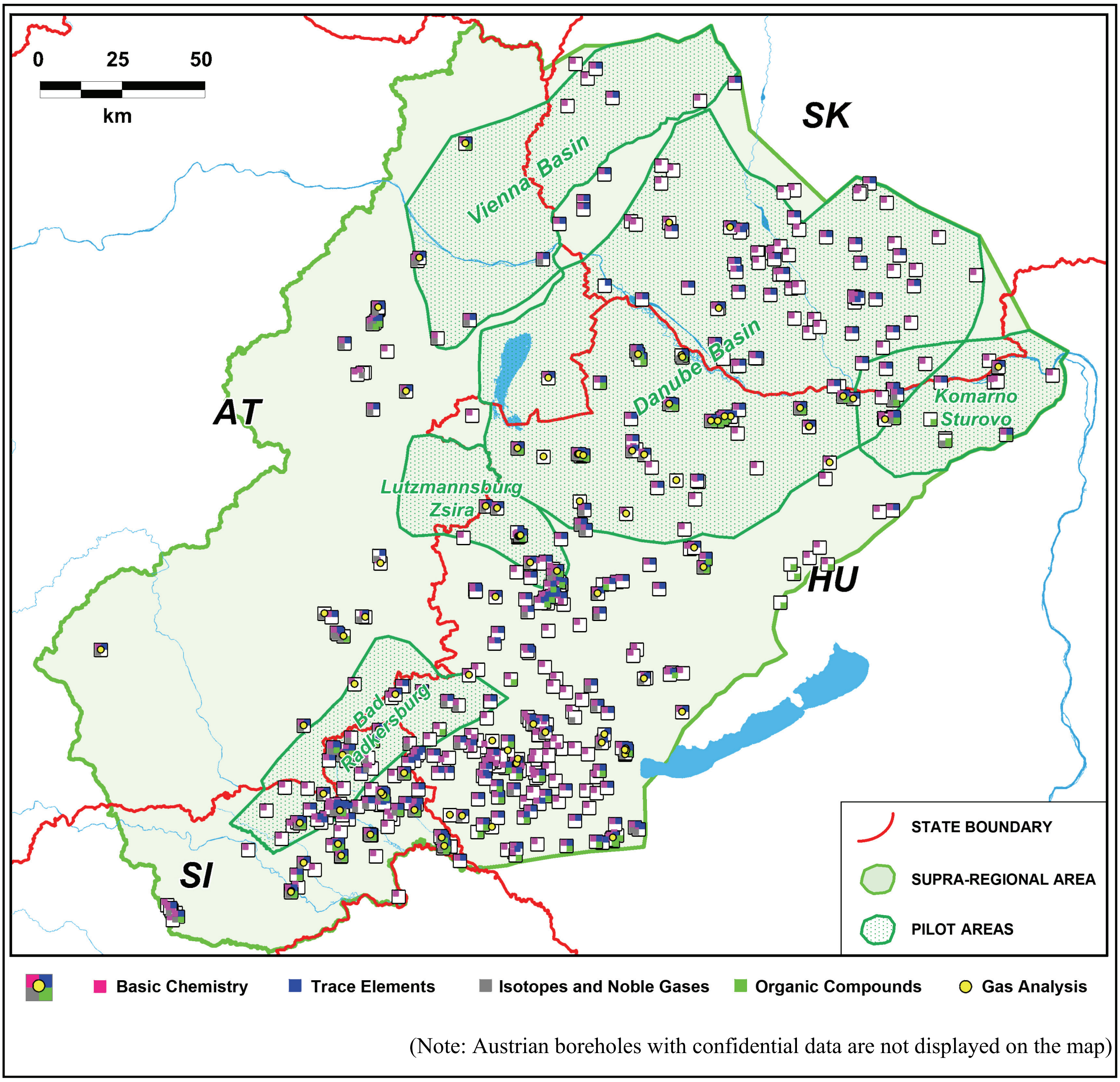


Figure 2.6.1: Spatial distribution of available hydrogeochemical data

Boreholes containing hydrogeochemical data cover all of the supra-region area in basins (excluding mountain regions). Highest density of boreholes is concentrated in the southern part of the Supra-region area. Nevertheless, distribution of data records within the pilot areas shows that the most of hydrogeochemical data comes from the Komarno-Sturovo area, where 38 457 data records comes from

16 objects (Figure 2.6.2). This can be caused by more measurements in the wells like long term monitoring activity in this area. Smaller amount of boreholes in the western and eastern part of supra-region results mainly from geological settings of these areas and the confidentiality of Austrian data.

From the map shown on Figure 2.6.1, is clear that most of the records belong to Basic chemistry group of parameters (93,15 % of hydrochemical data). In many boreholes, trace elements were also analyzed, but in total number of such analyses covers only 5,13 % of all hydrogeochemical data (Figure 2.6.3).

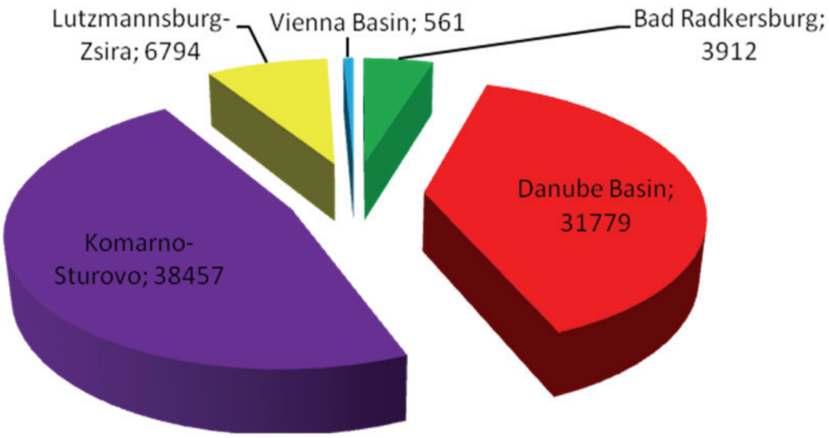


Figure 2.6.2: Amount of hydrogeochemical data records related to each pilot area

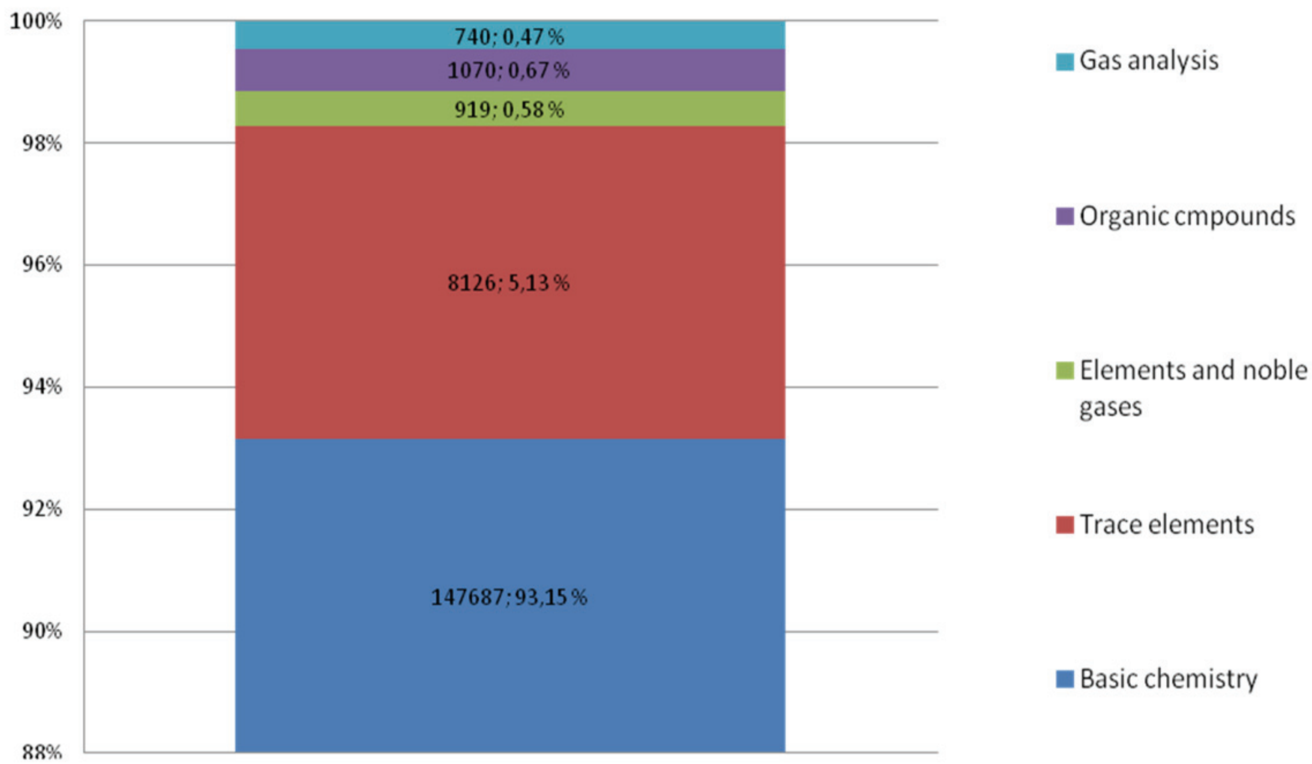


Figure 2.6.3: Number of data records according to selected hydrogeochemical parameters

Hydrogeochemical data distribution related to the depth is shown on Figure 2.6.4. Majority of records is found in the upper 500 meters, and with the depth the number of hydrogeochemical data is rapidly decreasing.

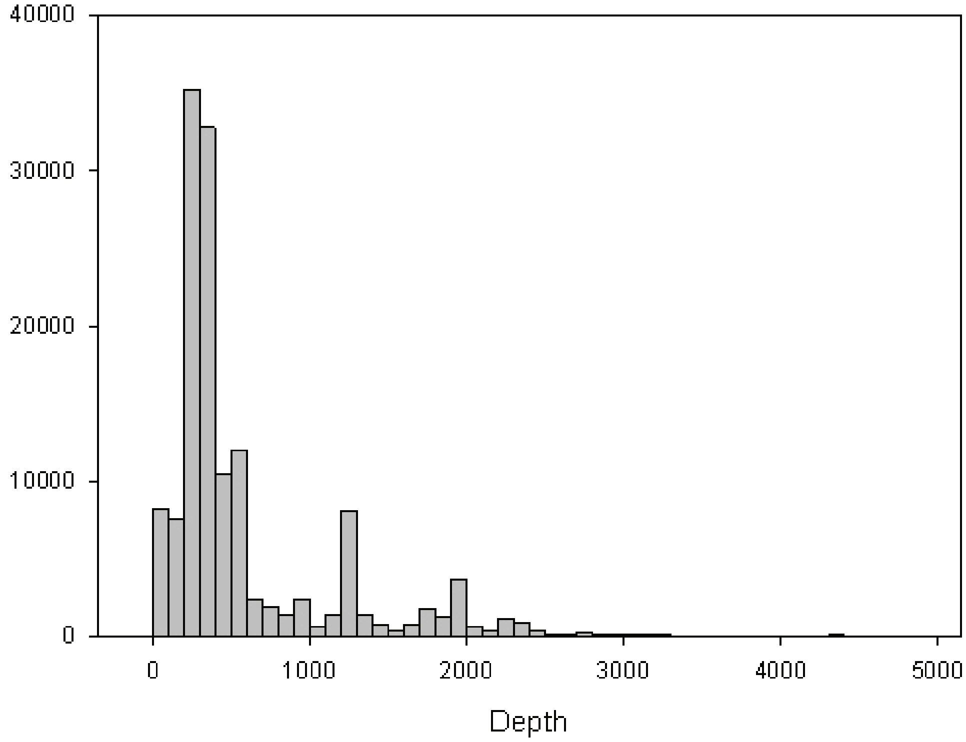


Figure 2.6.4: Numbers of hydrogeochemical records along the depth

3. Additional investigation and new data entries to the database

Additional investigation was part of transnational data management (WP4). Obtaining missing data, update older ones, especially from the near-border no-data areas were outlined in the report "Evaluation of datasets" (Mikita and Goetzl, 2011).

Additional investigations included field work (e.g. measurements in wells, sampling), laboratory work (e.g. geochemical analyses, petrophysical measurements). Collected data were incorporated in the TE database (WP4). Each of the partner's situations before and after data collecting can be seen on Figure 3.1. All figures and numbers presented in previous chapters already contain new additional data.

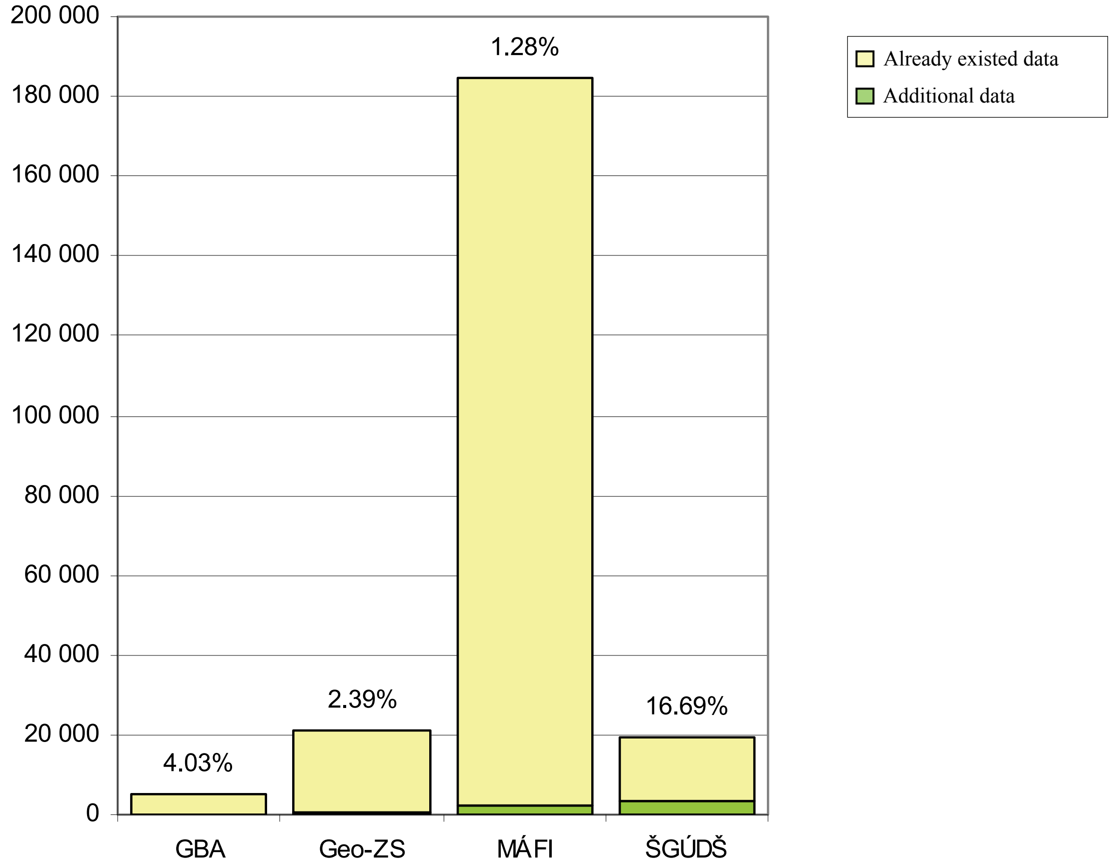


Figure 3.1: Comparison of new data entries into the database

A brief overview on additional data, according to individual partners and used methods is shown in Figure 3.2. (Separate report "Additional investigation" was already created within the WP4 activities - Mikita et al., 2011).

	MÁFI		GeoZS		GBA		ŠGÚDŠ	
	samples	*analysis*	*samples*	*analysis*	*samples*	*analysis*	*samples*	*analysis*
Chemical data	32	main components, trace elements	6	^{14}C and $\delta^{13}C$ in HCO_3^-	6	Basic chemistry	x	x
		^{14}C and $\delta^{13}C$ in HCO_3^-, tritium	6	$\delta^{18}O$, δD	6	Trace elements		
		$\delta^{34}S$ in water (SO_4^{2-})	6	TOC	4	Isotopes		
		$\delta^{13}C$, δ D in hydrocarbon (CH_4)	6	Noble gases				
		Noble gas	5	Dissolved and separated gasses				
		δ D, $\delta^{18}O$	3	Tritium				
		TOC	1	Organic compounds				
		Phenol index, Phenols (if index of phenol >20ug/l)						
		Acetate-propionate (if TOC >8), PAH (if TempH_2O>60^oC and COD>2)						
		F^-, S^{2-}, I^-, Br^-						
		Dissolved gas, Separated gas						
		Heavy hydrocarbon from dissolved gas, separated gas (if CH_4 is high)						
		Radon						
	objects	*parameters*	*objects*	*parameters*	*samples*	*parameters*	*samples**	*parameters**
Geophysical data	12	Natural gamma log measurements	7	Temperature log measurements	53	Thermal conductivity	66	Thermal conductivity
		Temperature log measurements			49	Heat capacity		Heat capacity
		Differential temperature log measurements			57	Radiogenic heat production		Heat flow density
		Borehole diameter log measurements			51	Density		Volume density
					49	Porosity		Porosity
								Geothermic gradient
								Temperature

* Note: Re-interpretation; x – no data

Figure 3.2: Summary on additional entries into the database

From selected objects, specific parameters were also investigated. In general two groups of data were obtained: chemical data and geophysical data (Hobinger, 2011; Gegenhuber, 2011; Lapanje, 2011; Rajver, 2011). Their spatial distribution is shown on Figure 3.3.

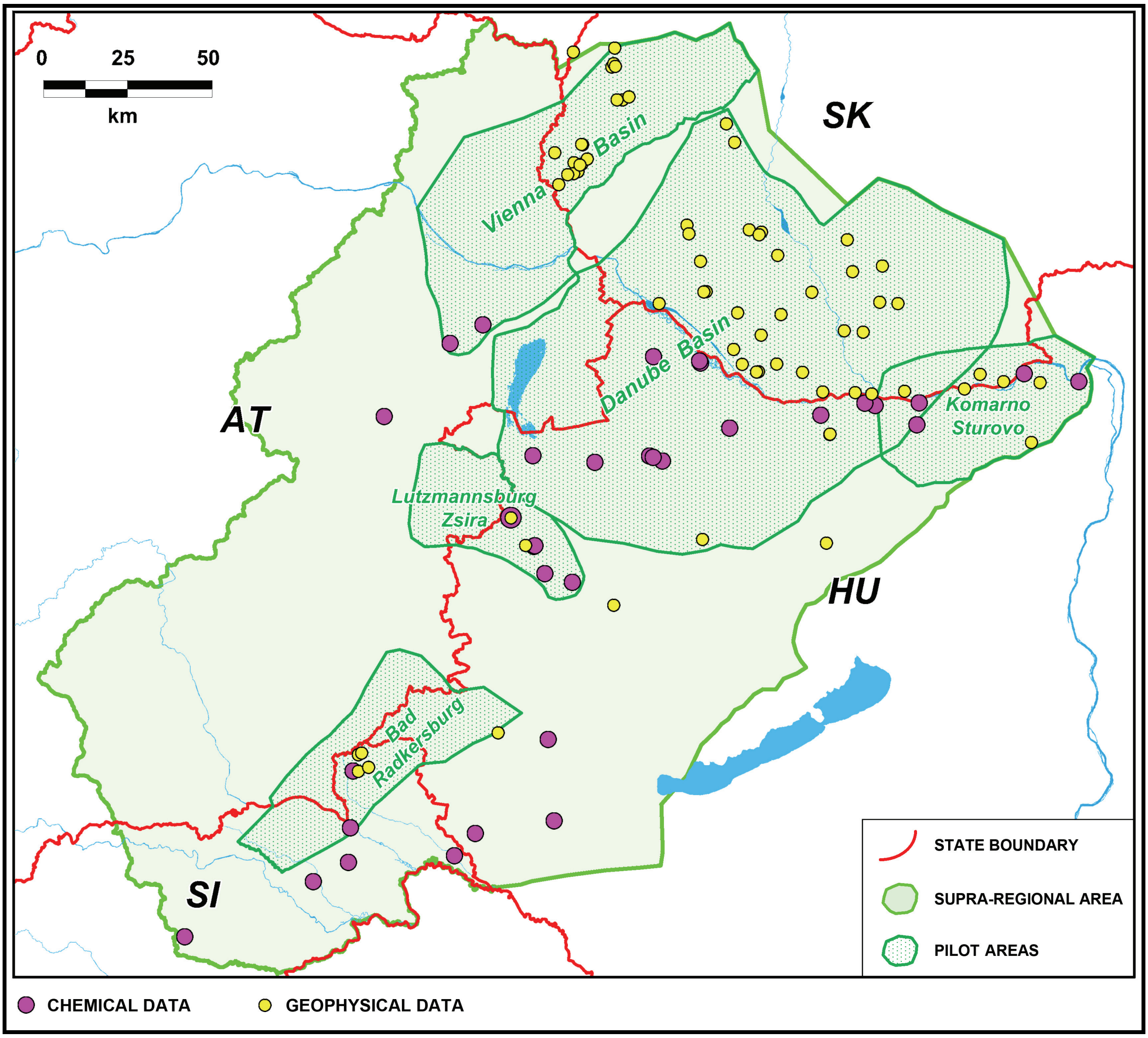


Figure 3.3: Spatial distribution of objects with additional data

To obtain proper data for every parameter, standardized methodology was used (Figure 3.4).

Figure 3.4: Field sampling of thermal water in Lébénymiklós well K-28

4. Publicity level of the data records in Transenergy (WP4) database

One of the main outputs from the WP4 - Expert database was to provide appropriate data for public on the web portal and use them like web-based multilingual geothermal resource information tool (public part of the WP4 - Expert database published through work package WP6 of the TRANSENEGY project). Aim of the public database is to offer reasonable information about geological, hydrogeological, geothermical and hydrogeochemical conditions of studied area not only for researchers (Expert database) or users (User database) but also to the stakeholders that do not have the professional background in the geological sciences. The ID of objects from User database is linked with ID objects in Expert database (so as well with ID of objects in Public database). Nevertheless that the structure and content of databases are not the same the information which they offer are complementary (Figure 4.1).

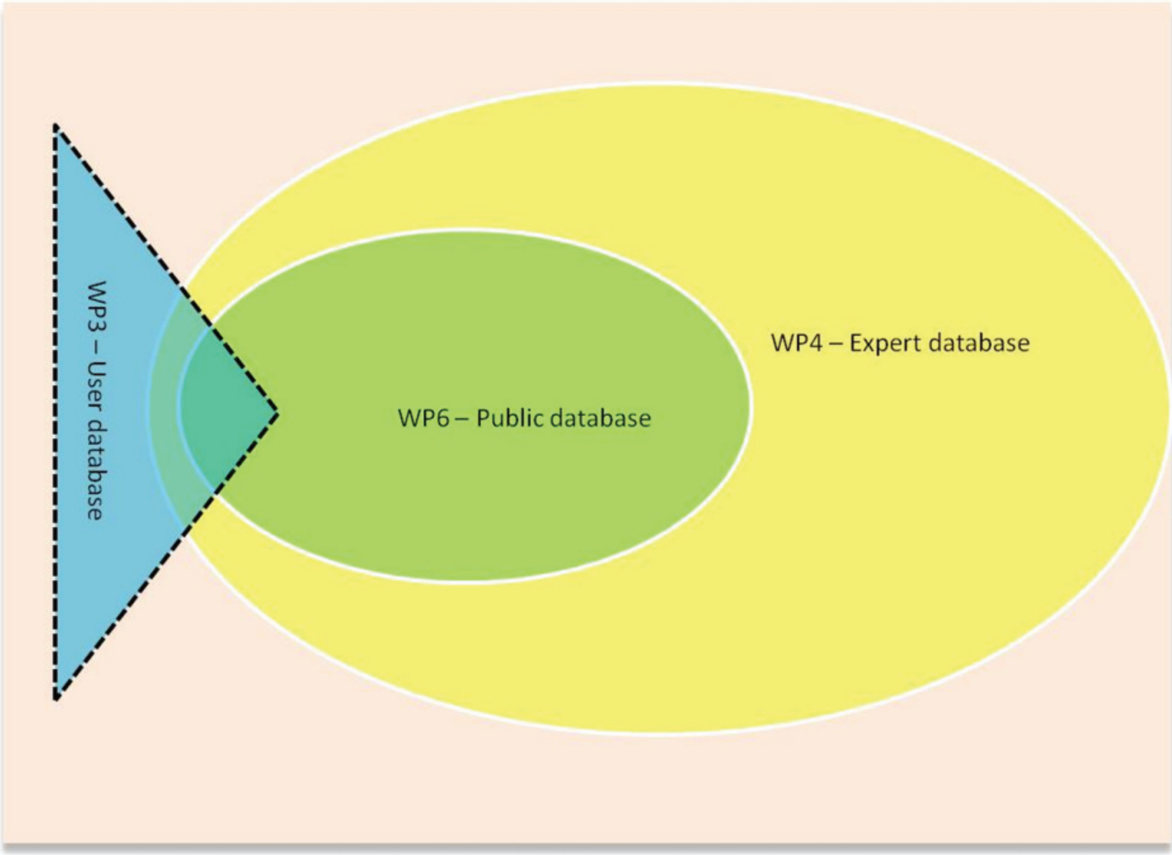


Figure 4.1: Schematic relation between various Transenergy databases

For the purpose of Public database, a reasonable selection of objects and parameters from WP4 “Expert” database was made by all partners. Amounts of objects selected from each partner to “Public” database are: **GBA – 115 (34.02 %); GeoZS – 128 (21.96 %), MÁFI – 742 (29.22 %), ŠGÚDŠ – 56 (16.47 %).** Spatial distribution of selected objects is presented on map (Figure 4.2).

The parameters that were designed for the publicity level are in Table 4.1. For better data evaluation and presentation parameters they were grouped into logical sections according the information they are offering: General, Geological, Hydrogeological, Geothermal, and Chemistry data.

A review on available data for public database with comparison of WP4 database is presented through amounts of data records related to particular groups of parameters (Figure 4.3).

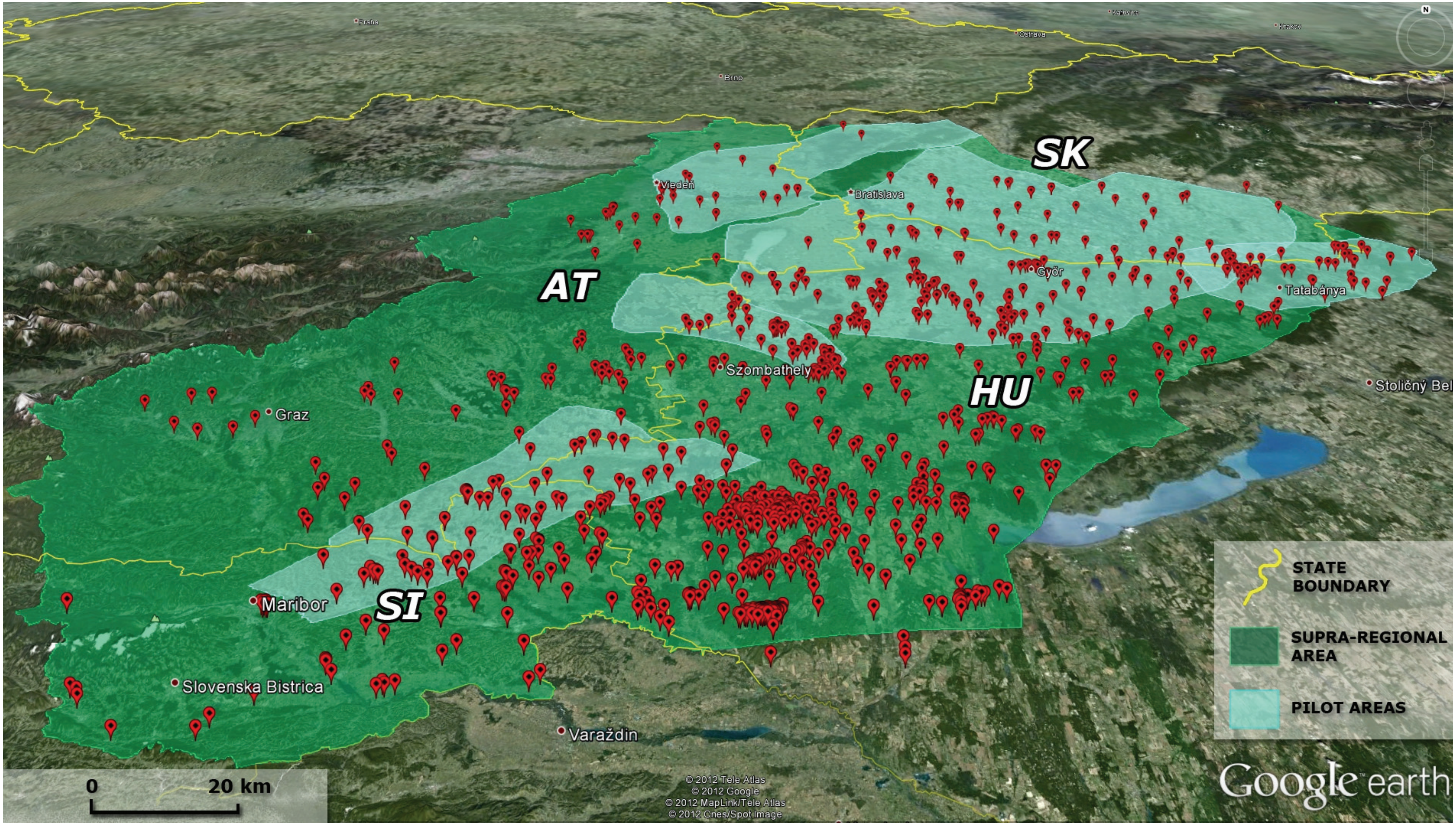


Figure 4.2: Spatial distribution of selected objects for the Public database

Table 4.1: Parameters available for publicity level from expert database

Group of parameters	Parameter of public database	Unit
General	name of the well/borehole/sprig	text
	coordinates X UTM	m
	coordinates Y UTM	m
	coordinates Z1 (top of casing)	m a.s.l.
	coordinates Z2 (surface elevation)	m a.s.l.
	coordinates	text
	locality	text
	year of drilling	y
	purpose of the well/borehole	text
	general	text
	depth1 (depth of drilling)	m
Geology	geology1	text
	depth of geology1	m
	geology2	text
	depth of geology2	m
	geology3	text
	depth of geology3	m
	geology4	text
	depth of geology4	m
	geology5	text
	depth of geology5	m
	geology6	text
	depth of geology6	m
	geology7	text
	depth of geology7	m
	geology8	text
	depth of geology8	m
	geology9	text
	depth of geology9	m
	geology10	text
	depth of geology10	m
Hydrogeology	aquifer porosity type	text
	top of screen	m
	bottom of screen	m
	number of screens	pcs
	total thickness of screening	m
	well head	m
	date of well head level measurement	date
	max. yield of the well/spring	l/s
Geothermal	temperature of water at wellhead	°C
	bottom/depth temperature	°C
	depth of bottom/depth temperature measurement	m b. s.
Chemistry	gas analysis	vol%
	total dissolved gas	m3/m3
	gas ratio	m3/m3
	basic chemistry, Na	mg/l
	basic chemistry, K	mg/l
	basic chemistry, Ca	mg/l
	basic chemistry, Mg	mg/l
	basic chemistry, NH4	mg/l
	basic chemistry, Fe	mg/l
	basic chemistry, Cl	mg/l
	basic chemistry, SO4	mg/l
	basic chemistry, HCO3	mg/l
	basic chemistry, HBO2	mg/l
	basic chemistry, Br	µg/l
	basic chemistry, F	mg/l
	basic chemistry, I	µg/l
	basic chemistry, H2SiO3	mg/l
	basic chemistry, TDS	mg/l
	basic chemistry, pH	-
	basic chemistry	mg/l
	basic chemistry	µS/cm
	basic chemistry	date

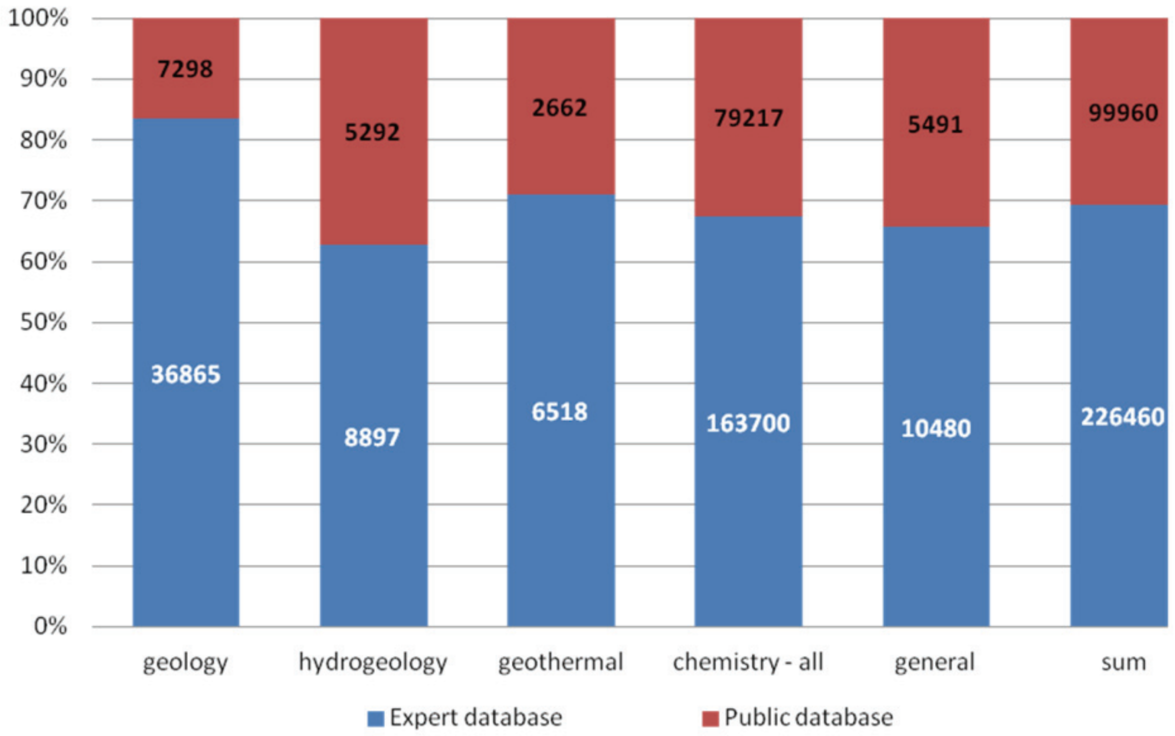


Figure 4.3: Proportion of data related to Expert database (blue) and Public database (red).

In general approximately 30 % of all data from WP4 database were included into WP6 database.

Public database contains also new data from additional investigations. Geological data have been harmonized by uniform legend, created to cover main (10) geological horizons.

High amount of data records obtained from various sources had to be managed in complex database with wide range of data categories harmonized, processed and completed for missing data. The team members had to check error entries in the database, record duplicities and had to translate the content of database into 5 languages. Adjustments were done by each partner, controlling his respective part of the data in the database.

5. Conclusions

The main result of work package WP4 of the TRANSENEGY project represents a functional database with harmonized datasets. It can be considered as **the first database of such kind in time that has been created by common effort of four countries of the Central European region.**

Transenergy database allows its users to join wide range of low uniformity data, and therefore enables **the comparison and evaluation of data throughout the investigated area that can be performed in a comfortable manner.**

The database serves its users to fulfill of the project aims and **can be used for different purposes** (Figure 5.1):

Figure 5.1: Various purposes for which Transenergy database can be applied

The database is organized in two main functional parts: the **back-end database**, containing raw data and the **front-end**, serving as a user interface, to which data are linked to. The back-end database is stored at the Oracle database server located at ŠGÚDŠ, the front-end appears in the file *Transenergy.mdb*. Such an approach has advantages in maintaining and upgrading the database is easier, as new versions of the front-end can be deployed independently of the back-end database. Since the data are stored on a centralized server with parallel access of multiple users, no local data is kept at client's side. Thus all project partners could work with data that is always up-to date.

Data in the database are stored as **point-source data related to particular objects**. Some of data are also connected to specific depth (e.g. geology, temperature, static water table) and date (e.g. chemical data, actual spring discharge). Storage format allows the data usage in 3D space and in some cases, chemical data can reflect time aspects as well.

During the database construction activities, it was necessary to standardize, harmonize, and complete the missing data, check duplicities and translate the content into English. Adjustments were done by each partner checking his respective part of the database.

Data included in the TRASENERGY database were analyzed and evaluated to understand their quality for further usage as geoscientific models inputs and to decide what kind of additional data should be obtained in further investigations. The data acquirement needs were focused primarily on cross-border pilot areas. Special care was also focused to recognize and repair incorrect data and records.

In **additional investigations,** various hydrogeochemical and geophysical data were obtained and included into the database. In total, 24,4 % of new data were added to the already archived ones. All data together were statistically processed and evaluated.

The database today contains 1686 objects involving 242 811 records represented in 453 individual parameters. Parameters are grouped in 13 different groups: General, Technical, Geology, Hydrogeology, Geothermal, Geophysics, Geothermometers, Utilization, Basic chemistry, Trace elements, Isotopes and noble gases.

Majority of the data represent hydrogeochemical parameters (69 %), being only of secondary importance. From the rest of the data (31 %), the most required in the forthcoming geoscientific modeling are those from parameter groups: “**Geology**” (16 %; geological data: 1 241 boreholes with 36 865 records), “**Hydrogeology**” (4 %; hydrogeological data: 738 boreholes with 8 897 records) and “**Geothermal**” (3 %; geothermal data: 786 boreholes with 6 518 records). The amount of data in particular data groups correspond to step by step approach, where the geological model is established first to serve as a base for the hydrogeological model, which is then followed by the geothermal model.

Data in the central part of Supra-region area are evenly distributed. The western and eastern parts of the Supra-region area are represented by mountain ranges (Alps and Transdanubian Central Range) with outcropswhere less point data (sourcing from boreholes) is present. Some less covered areas by borehole data like in the Vienna Basin, are due to confidentiality of Austrian data. However, all Austrian data will be incorporated in the process of geoscientific modeling as interpreted grid files.

Part of database is already available for public use, and will be published on the official site of Transenergy project. **The Public database** will serve like web-based multilingual geothermal resource information tool.

The ID of objects from User database is linked with ID of objects in Expert database (so as well with ID of objects in Public database). Nevertheless that the structure and content of databases are not the same the information which they offer are complementary.

Presented database will serve for international data management and harmonization, not only for the purposes stated in TRANSENERGY project, but also represents a good base for scientific knowledge improvement within the Central European region. As the topic of renewable resources becomes more up-to-day, the transfer of data among the countries offers also a good starting position for further prospective cooperation.

6. References

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Annex - Austrian confidential data

The Annex shows metadata from the Austrian confidential boreholes. In Austria it is not allowed to deliver the individual measurements, but they will be used during modeling. GBA will deliver the permeability etc. of the individual aquifers as Grids. The shown statistics and maps don't include the Austrian data from the common database.

Overview of presented parameters

- Total Porosity
- Effective Porosity
- Hydraulic Conductivity
- Hydraulic Permeability
- Bulk Density
- Hydro-chemical and hydro-physical Parameters:
  - TDS (Total Dissolved Solids), Evaporation Residue
  - Density at 20 degC
  - pH
  - Main Ions: K, Na, Ca, Cl, Mg, NH4, SO4, Fe
  - Acetate
  - CO3 (calculated), HCO3
  - SiO2
- Formation Pressure
- Shut-in Pressure observed at Hydraulic Tests
- Measured Temperatures

All shown boreholes feature geological stages.

Total Porosity

Definition: Fraction of total pore volume (hydraulic conductive and non-conductive)

Unit: %

Data-source(s): Measurements on drilling cores; interpretation of geophysical logs

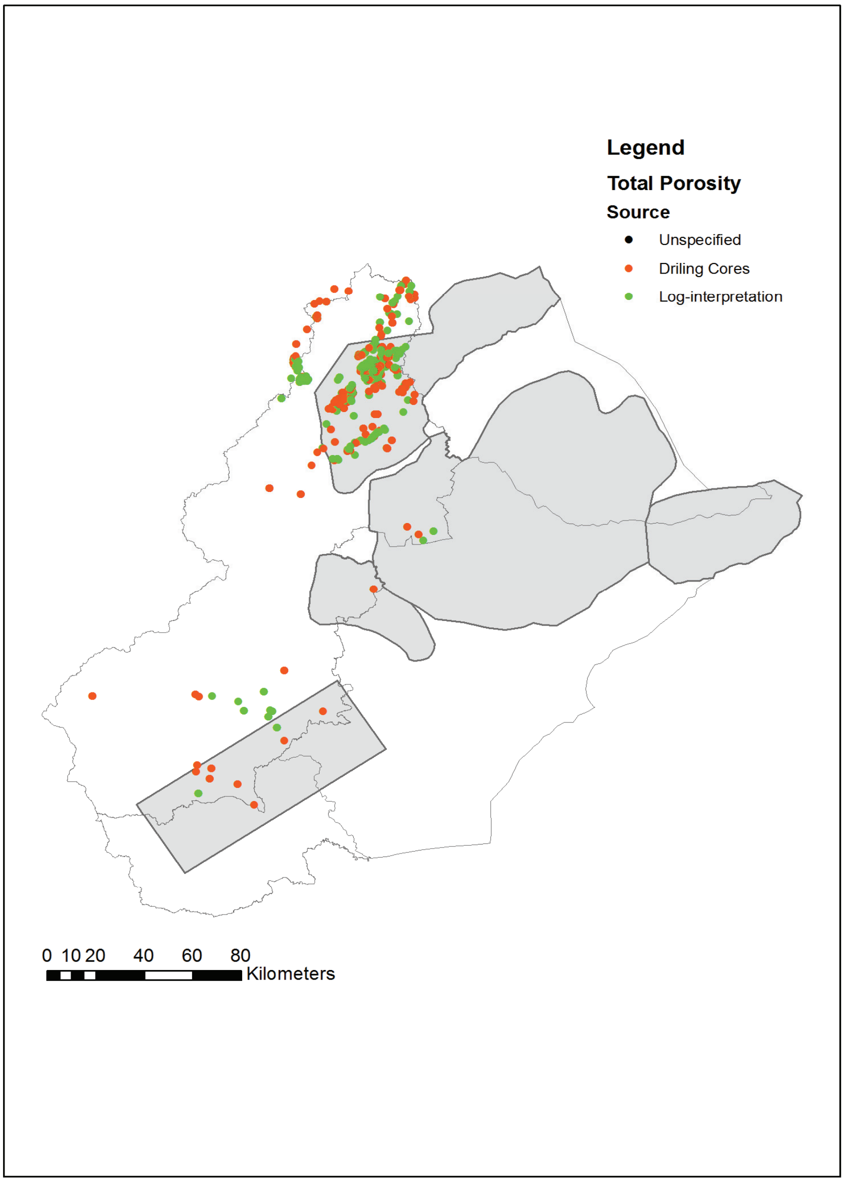
Descriptions: The total porosity according to drilling core measurements is primarily representing the attributes of the solid rock matrix; data from logging give a more comprehensive overview on reservoir conditions, but the available logging interpretation focuses predominately on potential hydrocarbon reservoirs at Neogene basin fillings

Data-processing: The available data are summarized for individual cores, geological units at specific wells and logging intervals (mean value)

Documentation: All data are aligned to depth intervals and geological units

Statistics:

- Number of boreholes with porosity data: 512
- Data from drilling cores: 749
- Data from log-interpretation: 1176
- Total sum at the supra-regional area: 1925



Effective Porosity

Definition: Fraction of hydraulic conductive pore volume

Unit: %

Data-source(s): Measurements on drilling cores; interpretation of hydraulic tests (modeling by hydrocarbon industry based on test results)

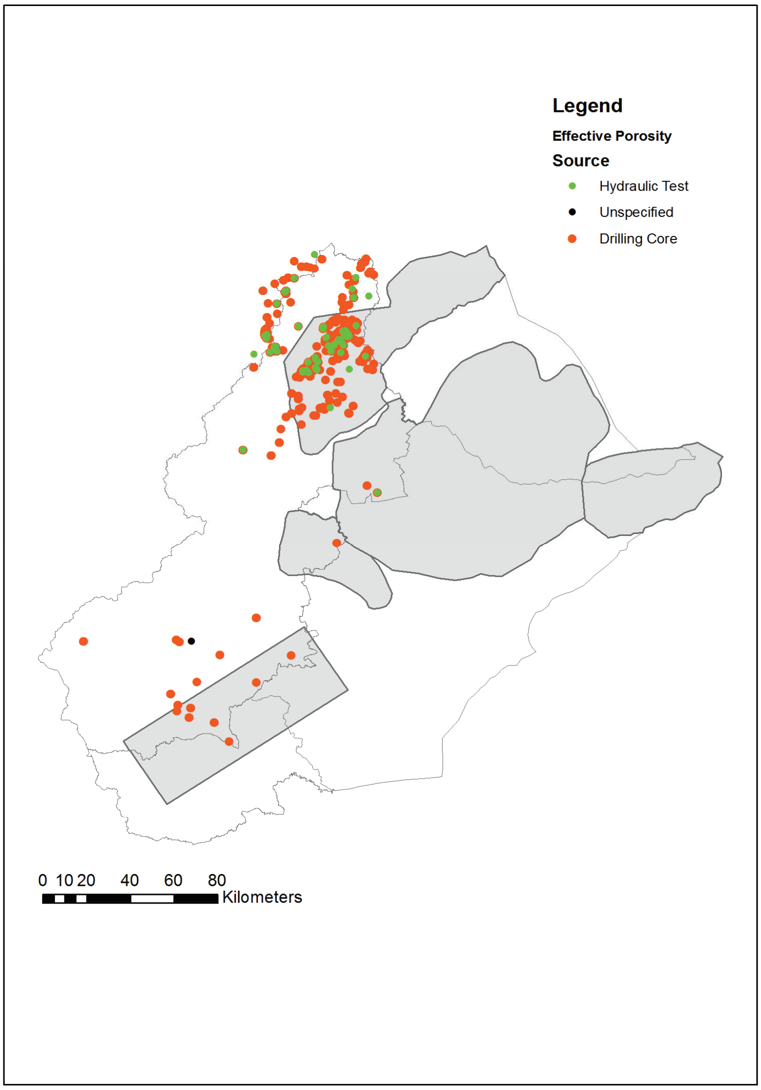
Descriptions: The porosity according to drilling core measurements is primarily representing the attributes of the solid rock matrix; data from hydraulic tests give a more comprehensive overview on reservoir conditions, but the available logging interpretation focuses predominately on potential hydrocarbon reservoirs, which don't necessarily have to coincide with geothermal reservoirs

Data-processing: The available data are summarized for individual cores, geological units at specific wells and test intervals (mean value)

Documentation: All data are aligned to depth intervals and geological units

Statistics:

- Number of boreholes with effective porosity data: 374
- Data from drilling cores: 1020
- Data from hydraulic tests: 76
- Unspecified: 2
- Total sum at the supra-regional area: 1098



Hydraulic Conductivity

Definition: Hydraulic conductivity at reservoir conditions (dynamic viscosity of formation fluid)

Unit: m/s

Data-source(s): interpretation of hydraulic tests (modeling) at geothermal wells

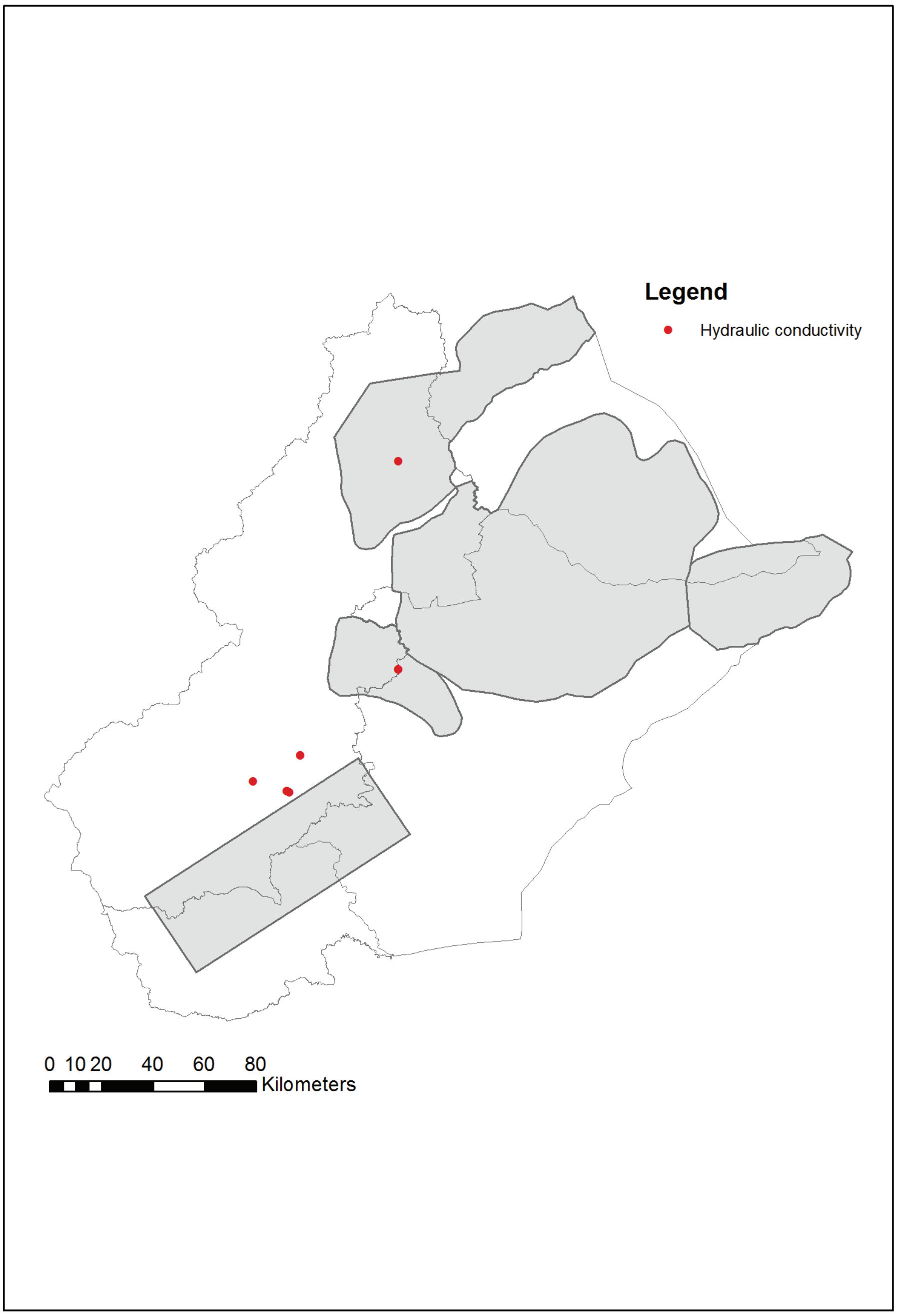
Descriptions:

Data-processing: Individual datum-points

Documentation: All data are aligned to depth intervals and geological units

Statistics:

- Number of boreholes with hydraulic tests for hydraulic conductivity: 7
- Total sum at the supra-regional area: 10



Hydraulic Permeability

Definition: Hydraulic Permeability of subsurface rocks regarding apparent anisotropy rate (value parallel and normal to rock foliation) gained from measurements of drilling cores

Unit: mD (Milli-Darcy)

Data-source(s): Measurements on drilling cores; interpretation of hydraulic tests (modeling by hydrocarbon industry based on test results)

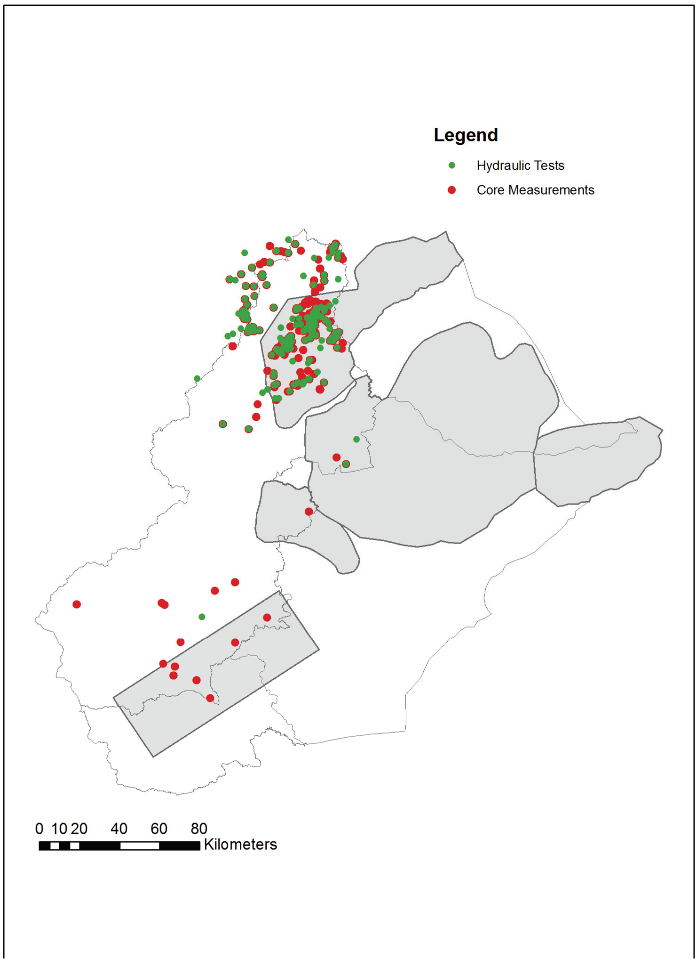
Descriptions: The permeability according to drilling core measurements is primarily representing the attributes of the solid rock matrix; data from hydraulic tests give a more comprehensive overview on reservoir conditions, but the available tests predominately focus on possible hydrocarbon reservoirs, which don't necessarily have to coincide with geothermal reservoirs

Data-processing: The available data are summarized for individual cores, geological units at specific wells and test intervals (mean value); data from drilling core investigations also contain horizontal (horizontal plane of drilling core) as well as vertical permeability (vertical plane of drilling core);

Documentation: All data are aligned to depth intervals and geological units

Statistics:

- Number of boreholes with hydraulic permeability data from hydraulic test: 208
- Number of boreholes with hydraulic permeability data from cores: 345
- Data from drilling cores: 12251
- Data from hydraulic tests: 349
- Total sum at the supra-regional area: 12600



Bulk Density

Definition: Rock Density including pore space

Unit: kg/m³

Data-source(s): Measurements on drilling cores; no data from log interpretation available

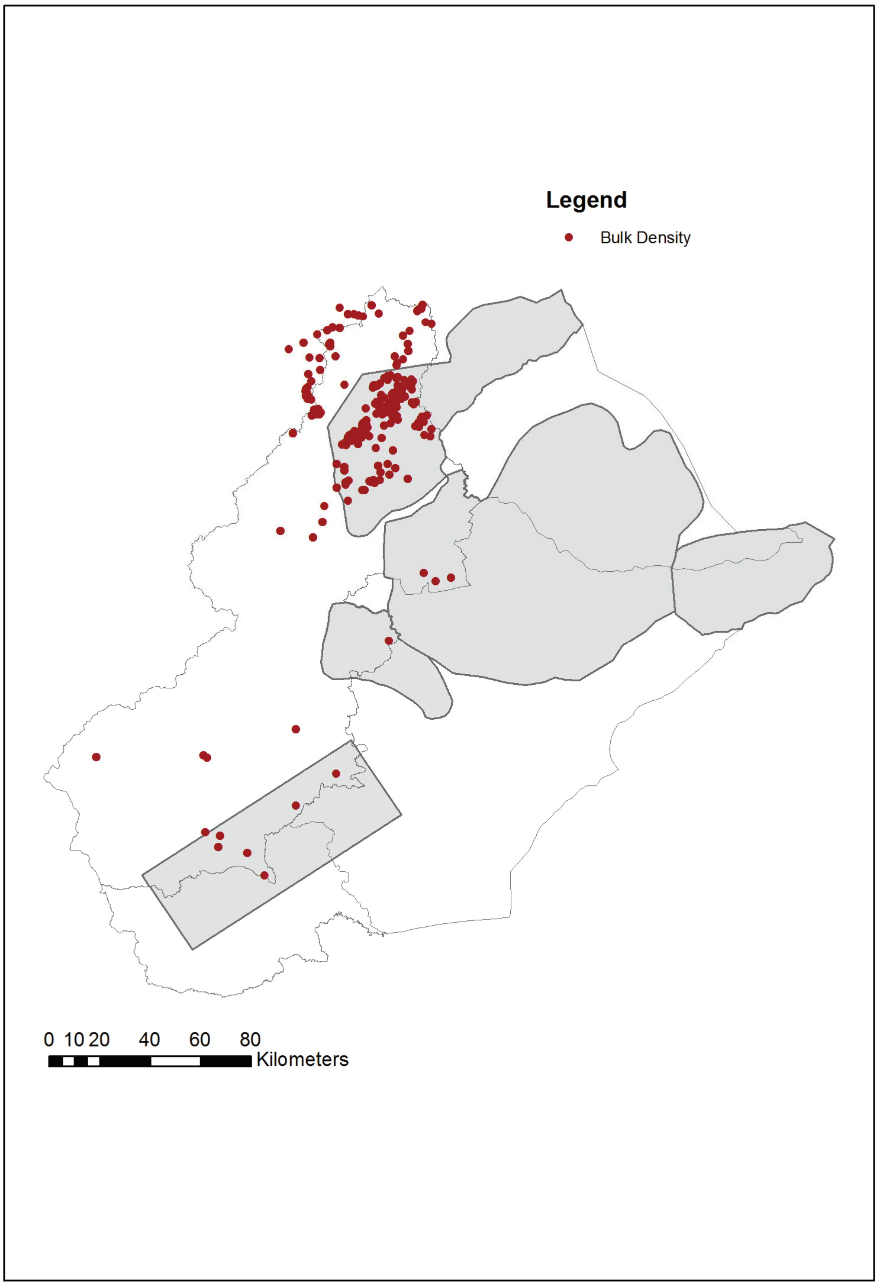
Descriptions: The permeability according to drilling core measurements is primarily representing the attributes of the solid rock matrix;

Data-processing: The available data are summarized for individual cores and geological units at specific wells (mean value);

Documentation: All data are aligned to depth intervals and geological units

Statistics:

- Number of boreholes with bulk density data: 325
- Total sum at the supra-regional area: 1040



Hydrochemical Parameters:

Definition:

(1) Total Dissolved Solid (TDS): Sum-up of measured main ions; Evaporation Residue at 105degC

(2) Density at 20 degC

(3) pH

(4) Main Ions: K, Na, Ca, Cl, Mg, NH4, SO4, Fe

(5) Acetate

(6) CO3 (calculated), HCO3

(7) SiO2

Units:

(1), (4)-(7) mg/l

(2) g/cm³

Data-source(s): Measurements on fluid samples primarily gained during hydraulic tests from hydrocarbon wells; measurements made by hydrocarbon industry

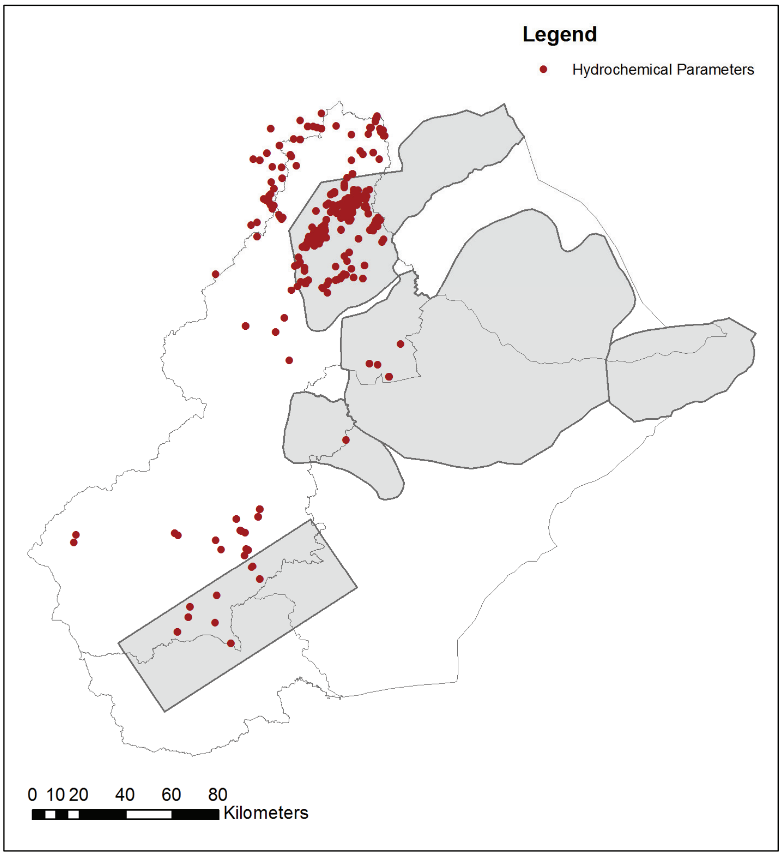
Descriptions:

Data-processing: Single values (no statistical treatment)

Documentation: All data are aligned to depth intervals and geological units

Statistics:

- Number of boreholes with hydrochemical and hydrophysical parameters: 351
- TDS: 3
- Evaporation Residue: 713
- Density: 553
- pH: 522
- K: 440
- Na: 756
- Ca: 761
- Mg: 761
- NH4: 778
- Cl: 796
- SO4: 767
- Fe: 704
- SiO2: 708
- CO3 (calculated): 634
- Acetate: 656
- HCO3: 71



Formation Pressure:

Definition: (1) Final shut-in pressure observed at hydraulic tests; (2) calculated formation pressure based on hydraulic tests; data predominately result from hydrocarbon exploration wells; it has to be kept in mind, that the available test intervals focus on potential hydrocarbon reservoirs and therefore make no claim to represent conditions at potential geothermal reservoirs in a comprehensive manner – especially at reservoirs with known lack of hydrocarbons;

Units: [atm]

Data-source(s): Hydraulic reservoir tests (Open Hole Tests, Casing Tests) from the hydrocarbon industry

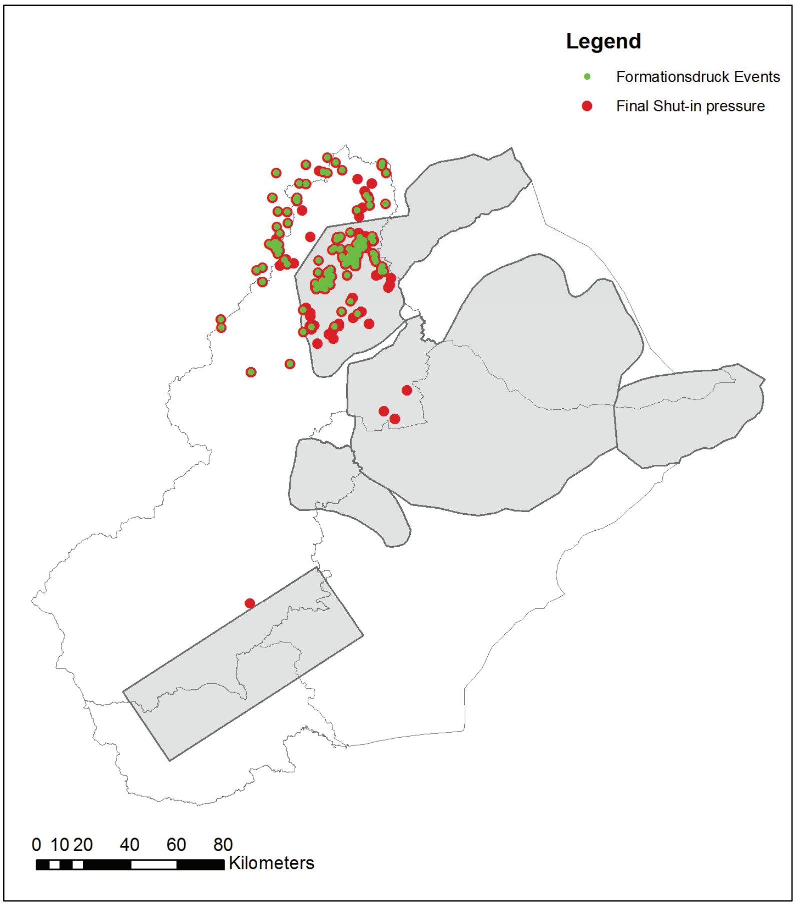
Descriptions: The final shut-in pressure represents the measured pressure at the end of the hydraulic test (pumping test) after a period of 2 hrs. to 4 hrs.; in general the final shut-in pressure is below the true formation pressure and can be seen as a minimum pressure at the reservoir; the true formation pressure has been calculated by modeling from shut-in pressure time series; the available data have already been processed by the hydrocarbon industry; the specific time series are not available;

Data-processing: Single values (no statistical treatment)

Documentation: All data are aligned to depth intervals and geological units

Statistics:

- Number of boreholes with calculated formation pressure based on hydraulic test: 201
- Number of boreholes with shut-in-pressure: 242
- Final shut-in pressure: 637
- Calculated formation pressure: 415



Formation Temperature

Definition: (1) Temperature measurement at hydraulic tests from the hydrocarbon industry (DST-data); (2) Corrected BHT measurements

Units: degC

Data-source(s): Hydraulic reservoir tests (Open Hole Tests, Casing Tests) from the hydrocarbon industry

Descriptions: DST-data have been gained during hydraulic tests and in most cases represent the true formation temperature and therefore don't have to be corrected for the influence of drilling and mud circulation (BHT correction); the main sources of error are represented by inflow of drilling mud (instead of formation fluids) at the testing probe and degasing (adiabatic cooling) during hydraulic tests; BHT data have been corrected for the influence of mud circulation based on graphical and numerical methods;

Data-processing: Single values (no statistical treatment)

Documentation: All data are aligned to depth intervals

Statistics:

- Number of boreholes with temperature data: 411
- Total Sum: 1658
- DST-data: 1142
- Corrected BHT-data: 516