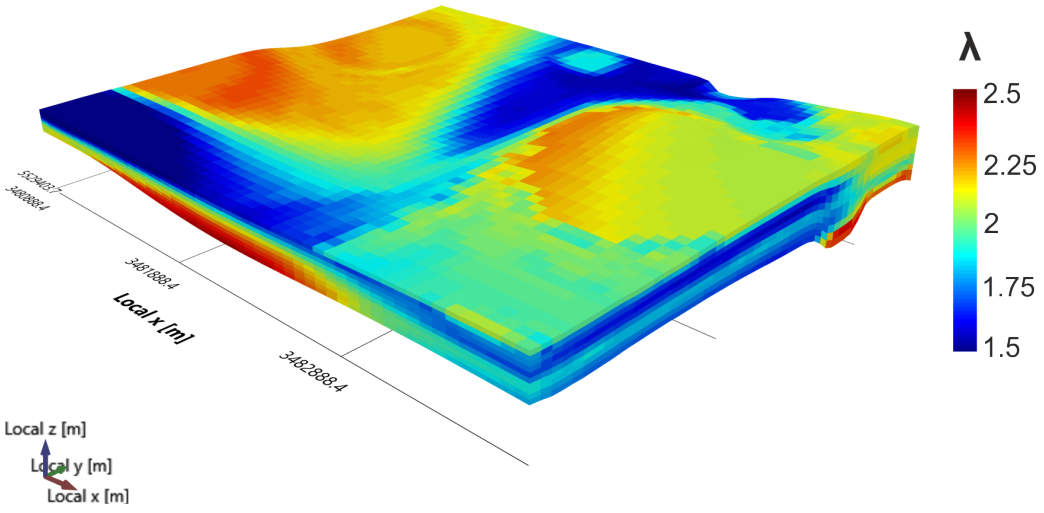
User Manual and Tutorial for GeoReVi

Geological Reservoir Virtualization

Date: October 25, 2019



Foreword

This manual is under preparation and subject to future changes.

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2 Introduction

GeoReVi is a software developed for geoscientific information management and knowledge discovery. GeoReVi can deal with many types of subsurface characterization yet being specialized on geothermal reservoir characterization. The software is developed under the MIT license making it free to use and open source.
The software is split up into two components. One component is the client application, the user interacts with, and the other component is the so called back end located either on an accessible server or on local machines. The font end uses a communication framework to access the database located in the back end.

2.1 Built with

- Entity Framework 6 - Database access
- HelixToolkit.WPF - Providing the 3D components
- Managed Extensibility Framework - Providing the modular structure of GeoReVi
- Accord.NET - Linear Algebra and Machine Learning framework
- Windows Presentation Foundation - Framework for creating Windows Desktop Applications
- Caliburn.Micro - Framework for MVVM development in XAML platforms
- FontAwesome.WPF - Providing nice icons
- DotSpatial - Spatial algorithms
- GeoAPI - Coordinate Conversion
- ProjNET - Coordinate Projection
- LiteDB - Embedded NoSQL database
- MoreLinq - Query helper

2.2 Authors and Contributors

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2.3 Hard- and software requirements

GeoReVi is built with the .NET Framework. This makes the software executable on every machine with Windows XP and newer OS. Since GeoReVi is a desktop database application, a valid connection to the database server has to be provided. When GeoReVi is used internally, please contact your admin for further assistance or use the software in local mode.
The software is tested under the following hard- and software configurations:

Hard-/Software	**Database**	**User interface**
OS	Windows Server 2012 R2	Windows 10
CPU	Intel Xeon CPU E3-1276	Intel Core i5-7200U
	v3 @ 3.6 GHz	2.5 GHz
RAM	24 GB DDR4	16 GB DDR4

2.4 Installation

The local version of GeoReVi can be started without installation. Therefore, simply execute the GeoReVi.exe file in the software folder.
To initiate a client-server architecture, a more advanced installation has to be performed. Researchers interested to establish a multi-user environment at their institute should feel free to contact us under contact@georevi.com via Email.

3 Getting started

Following section contains comprehensive descriptions on the data, algorithms and the software structure of GeoReVi.

3.1 Data management

Data produced in subsurface studies include various geoscientific domains like (petro)physics, sedimentology, hydrogeology, instrumental analytics or geophysics. GeoReVi facilitates the user to manage data sets from all of these entities. Entities like chronostratigraphy or petrography are supplied according to international standards like chronostratigraphic units from the International Chronostratigraphic Chart 2017 (ICC, 2013; updated) and the petrographic terms mostly by definitions from the British Geological Survey (BGS) or American Geological Institute (AGI).
Entities that are not standardized internationally were tried to be reduced on the most normalized level. Lithostratigraphy for instance provides a more or less internationally applied standard to subdivide units hierarchically like following:

1. Group
2. Subgroup
3. Formation
4. Subformation/Member

This schema was transferred into GeoReVi. Nevertheless, in contrast to the chronostratigraphic units, a user also has to be able to adapt information of a lithostratigraphic unit. Generally, data sets can be inserted, updated and deleted manually in accordance to common **CRUD** standards *(Create, Retrieve, Update, Delete)*. A user always works on one of the projects where subscription is provided. Every data set is equipped with the ID of the user who generated the data set. Only this user is allowed to update or delete associated data sets. Users with project subscription may retrieve data sets.

3.1.1 Provided data set

In the local application we provided a data set from one of our publications (Linsel et al. 2019). The data set is located in the "Disibodenberg" project. Here you find 41 rock samples (plugs) taken from the outcrop "Sandstone Quarry Obersulzbach". Additionally, you find

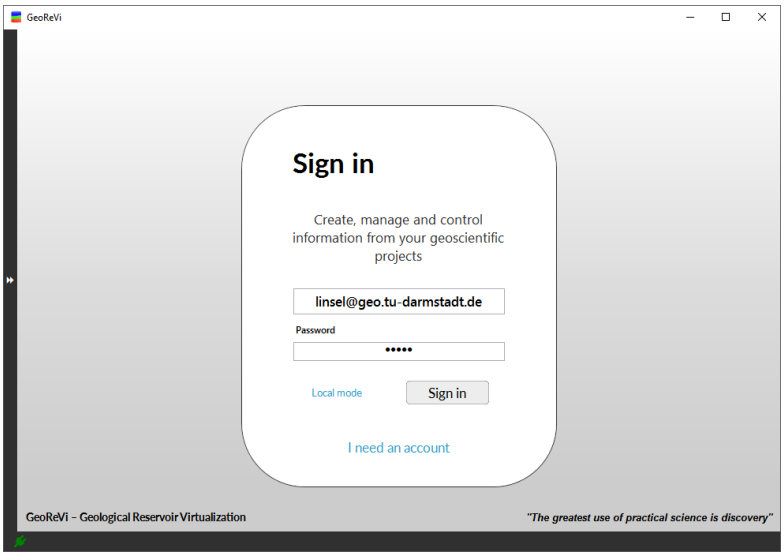

Figure 1: Login view.

3.1.2 Starting the application

First, the user will see the *Login* screen.
If a connection to the server database is established, the text block in the lower left corner is displayed in green color. Otherwise, the text block indicates a missing connection through showing a red color and associated text. If you are not registered in your institutional database yet go to the "Register and Sign In" chapter. Alternatively, you can work on a local database by clicking on "Local mode". When you work on your local database make sure that you update your database by clicking **Start –¿ Update LocalDB** to get the domain data for chronostratigraphy, petrography and facies analysis. After login, the user finds the main navigation menu in the top part of the main screen.
The general structure is

Start	**Data**	**Map**	**Help**
Home	Geological objects	Global Map	Documentation
Projects	Lithology		About GeoReVi
	Rock Samples		
	Measurements		

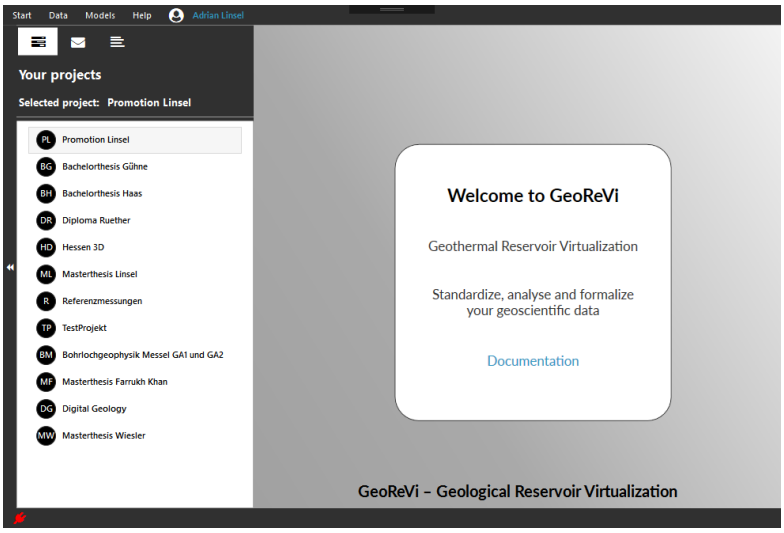

Figure 2: Home view with projects sidebar.

3.1.3 Registration and Sign in

After installation of the server database, the user can create an individual account to access data from GeoReVi. Therefore, the user has to create an account by providing information. Other users will see the email address and affiliation provided in the registration when inviting users to their projects. The information will be encrypted and stored in the database. The account can be deleted or user information can be changed under *My Account*.

Please, be aware, that all information you provided in GeoReVi won't be accessible anymore when you delete your account!

Your projects and its related data will exist further on and subscribed users will have access to the projects related data unless those are transferred to another project or deleted, too.
After successful registration, the user can sign in by the provided user name and password. At the beginning, the user doesn't have access to any projects but he can see objects of investigation for planning studies and field campaigns.
Projects, the user participates at, will be loaded after sign in and can be selected in the drop-down box next to the main navigation menu. After selection, the user will work on the selected projects and has access to data related to that. Most times, many people will work on one specific project. Therefore, only the uploader and the project creator will have writing-access to the data sets to avoid unwanted data manipulation.

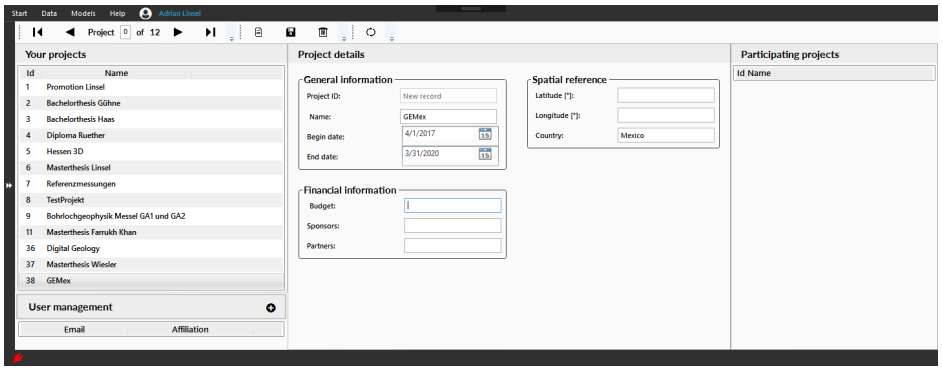

Figure 3: Projects view with a newly added project.

3.1.4 Project Management

Projects can be managed and created in the *Projects* menu. To improve the overview, duplicate project names are forbidden. Duplicate project names will be changed during registration and the user will be informed about it. After creating a project, the creator can add or remove users. By clicking on '+' in the user management frame a user can be added via dialog service. '-' will unsubscribe the participating user. A user can also unsubscribe from the project by clicking the '-' button in the 'Participating projects' frame.

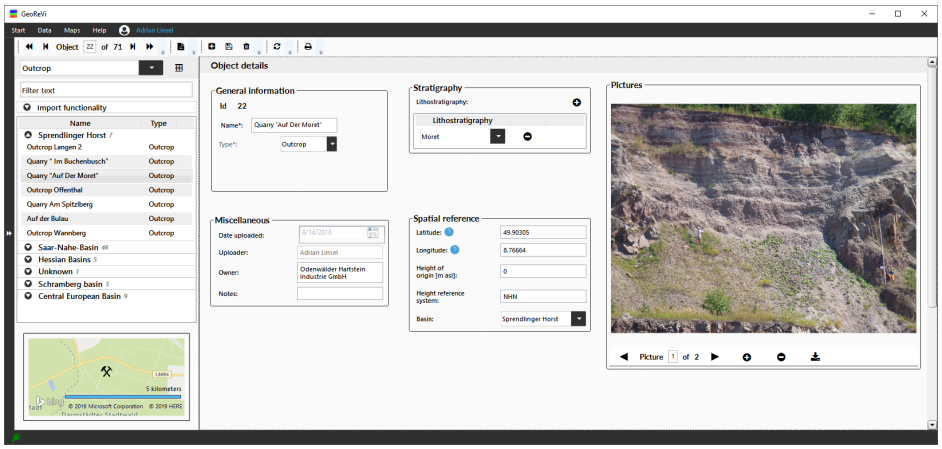

Figure 4: Objects of investigation form.

3.1.5 Objects of investigation

Objects of investigation are all object that can be investigated in a geoscientific context. You can get to the objects form via **Data –¿ Geological objects**. In GeoReVi you can differentiate between "Outcrop", "Drilling", "Transect" and "Water body".

3.1.6 Lithologies

Lithologies can be stored according to the lithofacies concept after Miall (1985). Here, geological units are subdivided into three classes namely lithofacies types, architectural elements and genetical units. Here applies

$$lithofaciestype \subset architecturalelement \subset geneticalunit \tag{1}$$

Lithologies can be updated in the "Lithologies" menu. When entering this menu you will find a tab-item with the names "Facies", "Architectural elements" and "Genetical units".

3.1.7 Measurements

When you navigate to the 'Measurements' view, you will find two types of measurements in two separate views. Laboratory measurements are measurements produced on a certain rock sample. When you open that view you can find the documented objects of investigations in the list on the left side. There you can select the rock sample where you want to archive a new measurement or from which you want to analyze the data. When selecting

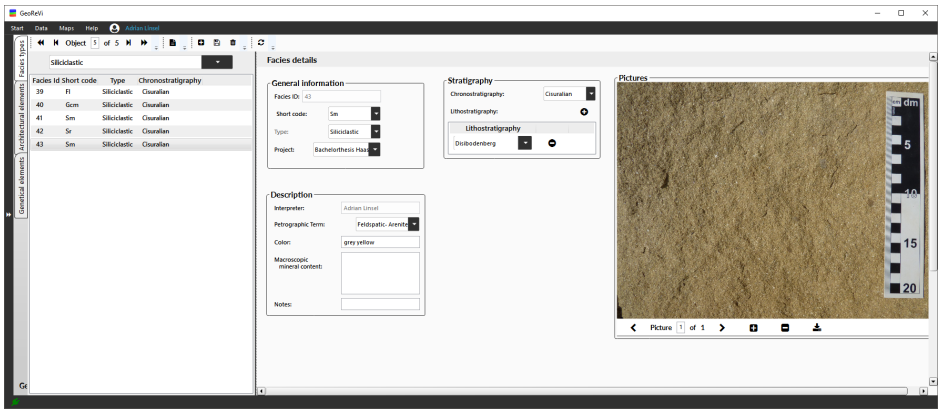

Figure 5: Lithologies form.

the rock sample, all types of measurements produced on that rock sample will be loaded and displayed in the list in the central part of the form.
Field measurements are measurements directly generated in or on an object of investigation. You can archive measurements such as well logs or structural measurements here. In the list on the left side you will find again all objects of investigation you documented beforehand. When selecting an object, all measurement related to that object are loaded in the list in the central part. To add measurements to a sample or to an object you can click the '+' button above the list view or you right-click on the list and select 'Add measurement'. A measurement of undefined type will be added to the list. To archive further information you will have to define the particular type of measurement under 'Type'. After saving the changes you can enter further information in the tab item 'Parameter'. If you want to import a set of measurements please refer to the chapter 3.1.8. To delete a set of measurement you can select multiple measurements in the list, right-click and select 'Delete selected measurements'. Confirm the order to delete the selected measurement and all of those will be deleted from the database.

3.1.8 Import to the database

Data can be imported from spreadsheet files. For import .XLSX and .CSV files with one header row are accepted. We recommend .CSV for import. Most data forms provide an import field in the left upper corner. This field can be expanded and the preferred import objects can be selected. Please ensure, that the .CSV cells provide the correct format (number, string, date, etc.). For file-import, the file containing the data has to be dropped into the border of the field. A file-import dialog will show up immediately, where the

imported data columns have to be mapped to the existing database headers. Therefore, single headers from the import file and from the database can be selected and mapped together with the map button. Headers can also be mapped automatically by using the mapping wizard. This algorithm checks for similar headers and maps them automatically.
Some database tables require redundancies for import. For instance, a plug must contain the sample name twice, since two tables are connected via this name to each other. Hence, two columns containing the sample name have to be included into the import spreadsheet. Also, following entities contain **obligatory** fields, where a value has to be provided:

1. Rock samples
2. Objects of investigation
3. Measurements

Please check beforehand, that the provided cells in the selected file have the adequate data format for the imported entity.
Exemplary proceeding

1. Open the rock sample form under **Data –¿ Rock samples**
2. Expand the import field by clicking on the **Import functionality** expander
3. Select the type of object you wish to import, in our case, this is the **Plug** sample type
4. Drag & Drop your .XLSX or .CSV files with the rock sample information on the import field
5. In the import form, corresponding headers have to be mapped. This can be done one after another by selecting the headers in the select and by clicking the right-arrow. The mapping will show up in the right mapping-list. An automatic mapping can be done by clicking the "Auto connect" button. This will map headers with identical names together and adds the connection to the mappings list. It is recommended to use the .CSV lists from the data exports since those provide the same headers as required in the import form.

3.2 Data analysis and visualization

Data analysis and visualization takes place in the 'Measurements' view. The lower part of the form is build up by data sheets, statistic forms and charts where you can analyze and visualize your data. To load a set of univariate, spatially referenced measurements click the black 'Load univariate data set' button above the lower form. This will download all measurements from the selected type from all samples where the selected sample belongs to. For example when you have the 'Porosity' measurement of a sample called 'OSB1' selected and you click the button, all data of the selected combo box property from all rock samples belonging to the associated outcrop will be loaded in the univariate data sheet.
All data that is loaded in the univariate data sheet will be treated as a 'Mesh'. A mesh is a structure with vertices or nodes, faces and cells. When you load a data set it is a set of scattered, unconnected vertices. You can add the selected data sets to chart objects by right-clicking on the sheet and selecting the wanted option. If you want to create for instance a depth log of a property you have to right-click and select 'Add to line chart'. Then navigate to the line chart by 'Charts –¿ Line chart' and select 'Z-direction'. When clicking the 'Refresh' button in the upper right corner, the graph will be drawn.

3.2.1 Mesh generation

Each data set handled in the measurements view is a mesh. Meshes in GeoReVi consist of nodes (vertices), faces and cells. Additionally, a datatable is associated with each mesh that holds the measurement values. Data sets loaded from the database or from a .CSV, .XLSX or .XLS file are imported as discrete points into the data table without nodes, cells or faces. You can edit or remove single values in the data table displayed.
Meshes can be used to create other meshes. To create a simple hexahedral mesh in the bounding domain of one or more meshes. Expand the menu on the left side of the data set view. Under *Source data sets* you can select the meshes that should serve as source data sets for the meshing process. When you open the *Discretization* expander you can find define the type of mesh that should be created, the boundaries as x, y and z coordinates and the step width in each direction.
You can create one-, two- and three-dimensional meshes. By default GeoReVi creates three-dimensional meshes. The dimension of a mesh is controlled by the step width. By selecting a step width of 0 this dimension will be removed. If, for instance, step width z is reduced to 0, and x and y is kept as

20, a two-dimensional grid with 20 faces in x and 20 faces in y direction will be created. Similar, if two dimensions are reduced to 0, a line grid will be created.

Digital elevation models Based on the API provided by **Open-Elevation** Each node in a mesh created in GeoReVi is indexed according to a regular mesh

3.2.2 Spatial interpolation and simulation

In the following section, we will explain how to interpolate values from one or more source data sets to a target mesh. To reduce the content in this section, we will cover the most important algorithms with examples. For more details on the theory behind the interpolation and simulation algorithms we will refer to the textbooks of Wackernagel (2003) and Webster & Margaret (2007).

3.2.3 Multivariate statistics

3.3 Supported data types

Data from various geoscientific disciplines is supported in the GeoReVi databases. Many types of information necessary for geothermal reservoir rock characterization are accomplished and rationalized in a multidisciplinary data model. Following information can be processed by the databases:

1. **Lithology**
   (a) lithofacies
   (b) architectural elements
   (c) genetic units
   (d) lithological logs
2. **Geological objects of investigation:**
   (a) outcrops
   (b) drillings/wells
   (c) geophysical transects
   (d) hydro(geo)logical objects
3. **Field/drill core samples**
   (a) cylinders/plugs

(b) cuboids
(c) handpieces
(d) thin sections
(e) powders
(f) soils
(g) sediments

4. **Analytical instruments**

5. **Laboratory measurements**

(a) grain density
(b) bulk density
(c) effective/total porosity
(d) apparent/intrinsic permeability
(e) (saturated) thermal conductivity
(f) thermal diffusivity
(g) (saturated) p- and s- wave velocity,
(h) bulk geochemistry (oxides and trace elements)
(i) isotopes
(j) electrical resistivity
(k) rock strength (uni- and triaxial)
(l) grain size

6. **Field measurements**

(a) spectral γ-ray
(b) total γ-ray
(c) magnetic susceptibility
(d) palaeo flow
(e) bedding
(f) lineaments
(g) joints
(h) temperature

(i) sonic log

(j) rock quality designation index

(k) hydraulic head

(l) bounding surface locations

7. **Stratigraphy**

(a) lithostratigraphic units

(b) basins

All those entities include meta-information like measurement conditions, subtype definitions or detailed descriptions. However, the visualization and analysis functionality of GeoReVi can be used with local data of any kind as well. Users are encouraged to send us suggestions for data, they would like to have available in GeoReVi too. Please address your requests to contact@georevi.com. We will try to answer your requests as soon as possible.

4 Personal data security

The database where GeoReVi stores user information is located on a local server or in the cloud which is dependent on the infrastructure provided by your administration. Passwords and user messages are encrypted and secured in a database management system. For internal communication, the implemented message service can be used. Messages are peer-to-peer encrypted and stored in the database.

References

[Rn3] Chart or Table. 2013; updated. URL: http://www.stratigraphy.org/ICSchart/ChronostratChart2017-02.pdf.

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