T-JAM

SI EUROPEAN TERRITORIAL COOPERATION HU

OPERATIONAL PROGRAMME SLOVENIA-HUNGARY 2007-2013

JOINT THREE-LINGUAL GEOTHERMAL DATABASE

within the framework of project

Screening of the geothermal utilization, evaluation of the thermal groundwater bodies and preparation of the joint aquifer management plan in the Mura-Zala basin

T-JAM

REPUBLIC OF SLOVENIA
GOVERNMENT OFFICE FOR LOCAL SELF-GOVERNMENT AND REGIONAL POLICY

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RAZVOJNA AGENCIJA SINERGIJA
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GeoZS

NYUDU-KÖVIZIG

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1. Introduction

The borehole data from Slovenian and Hungarian project area were gathered, joined and harmonized in an *expert database* prepared in the Microsoft Office Access. The *expert database* contains all available technical, geological, hydrogeological, geothermal, geochemical and utilization data on each well separately. Most of this data is owned by borehole managers and is not public. Therefore this database is used only by project partners for various geoscientific interpretations. However, the most representative data interesting also for the thermal water users and the wider public is compiled and published in a *public database*. *The public database* is prepared as a user friendly web application in which the borehole geographic location is directly connected to the geoscientific data at the chosen location. This web-application is available through the project website (www.t-jam.eu).

2. Transboundary geoscientific data harmonization

When geoscientific data from Slovenia and Hungary was compiled into the database, it became evident that due to the different systems in the two countries additional harmonization is needed in order to have a coherent picture. Consequently, unified suggestions for different groups, such as drilling purpose, borehole status, type of water use, aquifer porosity and geothermal system (Hochstein) type, were agreed upon and are shown in the following tables.

Table 1. Drilling purpose options

raziskave premoga	coal research	szénkutatás
ogrevanje z geotermalno energijo	geothermal heating	geotermális fűtés
skladiščanje zemeljskega plina	gas storage	gáztároló
geotermalna vrtina	geothermal borehole	geotermális fúrás
hidrogeološka vrtina	hydrogeological borehole	hidrogeológiai fúrás
izvir	natural spring	természetes forrás
raziskave nahajališč nafte in zemeljskega plina	oil and gas prospection	olajkutatás, gázkutatás
reinjekcija	reinjection	visszasajtolás
strukturna vrtina	structural borehole	szerkezetkutató fúrás

Table 2. Borehole status options

opuščena vrtina	abandoned borehole	felhagyott fúrás
opuščena zaradi tehničnih težav	abandoned due to failures	elszerncsétlenedett kút
cementirana vrtina	cemented borehole	cementezett fúrás
zaprta vrtina	closed borehole	lezárt fúrás
likvidirana vrtina	liquidated borehole	megszüntetett fúrás
opazovalna vrtina	observation well	figyelőkút
proizvodna vrtina	production borehole	víztermelő fúrás
konzervirana vrtina	preserved borehole	fenntartott fúrás
neznano	unknown	nem ismert

Table 3. Type of water use options

klimatizacija prostora (ohlajanje)	air conditioning (cooling)	légkondícionálás (hűtés)
uporaba v agronomiji	agricultural use	mezőgazdasági használat
gojenje živali	animal farming	állattartás
kopanje in plavanje (vključena balneologija)	bathing and swimming (including balneology)	fürdő és strand (beleértve a gyógyfürdőt)
reinjekcija CO2	CO2 reinjection	CO2 besajtolás
daljnsko ogrevanje (brez toplotnih črpalk)	district heating (other than heat pumps)	távfűtés (nem hőszivattyús)
pitna voda	drinking water	ivóvíz
pridobivanje elektrike	electricity production	elektromos áram termelés
ogrevanje rastlinjakov in tal	greenhouse and soil heating	melegház- és talajfűtés
podzemne toplotne črpalke	groundwater heat pumps	talajvíz hőszivattyúk
toplota za industrijske procese	industrial process heat	ipari termelési hő
vrtina za namakanje	irrigation well	öntözőkút
posamezno ogrevanje prostora (brez toplotnih črpalk)	individual space heating (other than heat pumps)	egyedi fűtés (nem hőszivattyús)
tehnološka voda	industrial water	ipari víz
likvidirana vrtina	liquidated borehole	megszüntetett fúrás
mineralna voda	mineral water	ásványvíz
ni uporabe - neuspešna raziskava	no use - negative research	nem hasznosított - eredménytelen kutatás
ni uporabe	no use	nem hasznosított
drugo	other	egyéb
vrtina za opazovanje (piezometer)	observation well (piezometer)	figyelőkút
ni uporabe - pripravljena za uporabo	no use - prepared for future use	nem hasznosított - jövőbeli hasznosításra előkészítve
reinjekcijska vrtina za vodo	water reinjection well	vízvisszatápláló kút
taljanje snega	snow melting	hóolvasztás
izvir	natural spring	forrás
neznano	unknown	ismeretlen
ogrevanje sanitarne vode	sanitary water heating	egészségügyi vízmelegítés

Table 4. Aquifer porosity type options

medzrnska poroznost	intergranular porosity	elsődlages (szemcsközi) porozitás
razpoklinska poroznost	fissured porosity	másodlagos (repedezett) porozitás
kraška in razpoklinska poroznost	karstic and fissured porosity	karsztos és repedezett porozitás
manjše in omejene vodonosne plasti	minor and limited water-bearing layers	korlátozott víztartó képességű réteg
plasti brez podzemne vode	aquiclude	vízzáró réteg

Table 5. Aquifer geothermal system (Hochstein, 1988) type options

vodonosnik v sedimentnem bazenu	sedimentary basin aquifer	üledékes medencebeli víztartó
vodonosnik v podlagi sedimentnega bazena	basement aquifer	alaphegységi víztartó
sistem toplih izvirov	warm spring system	melegvíz forrás
sistem toplih izvirov in vodonosnik v podlagi sedimentnega bazena	warm spring system and basement aquifer	melegvíz forrás és alaphegységi víztartó
vodonosnik v sedimentnem bazenu in v podlagi bazena	sedimentary basin and basement aquifer	üledékes medencebeli és alaphegységi víztartó
sistem toplih izvirov in vodonosnik v sedimentnem bazenu	warm spring system and sedimentary basin aquifer	melegvíz forrás és üledékes medencebeli víztartó

3. T-JAM expert database

As already mentioned in the introduction, the majority of the geoscientific data is compiled in the project expert database. Most of the collected data cannot be published therefore it is used for interpretations and preparation of geoscientific models done by the project partners. Data collected in the expert database and relations between different data tables in the Access database are shown on Fig. 1.

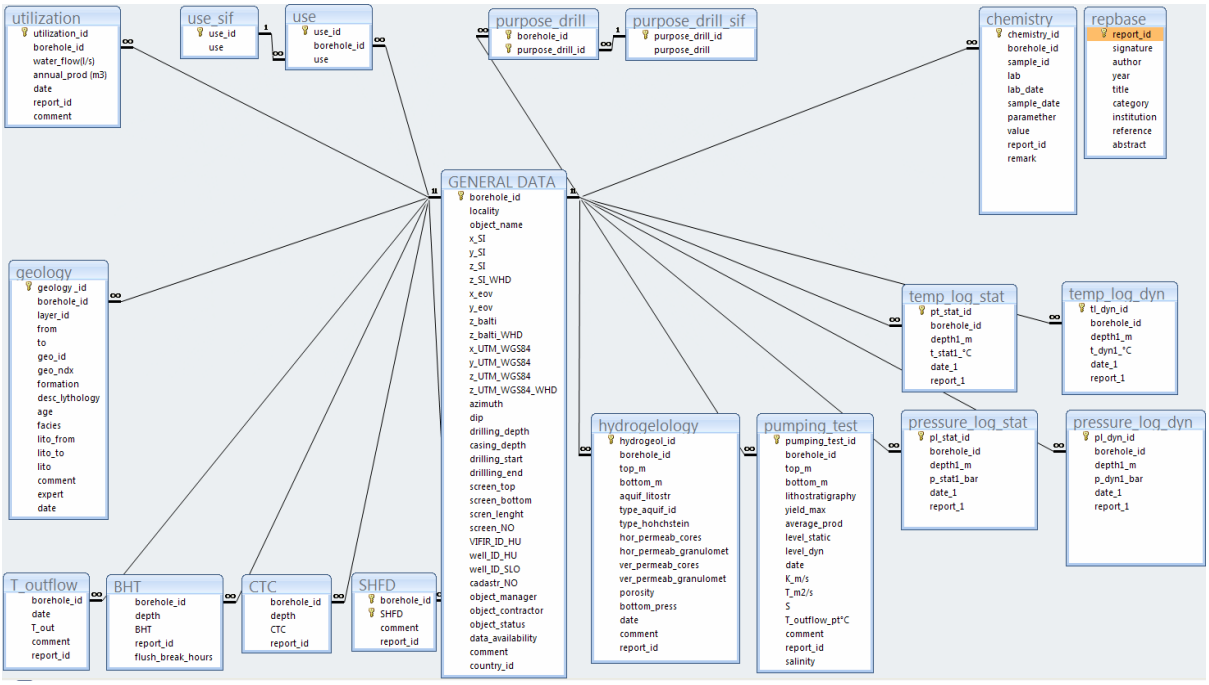

Fig. 1. Relations and connections between the data tables in the T-JAM expert database

The amount of assembled data varies between the countries (Table 6). The difference is obvious in the number of boreholes, which is partly related to the disparity of area sizes, and partly to the number of boreholes drilled for the exploration of natural resources. Afterwards, this directly results in more geological data from Hungary than from Slovenia. In contrast, Slovenia has much more specific hydrogeological and geothermal data available.

Table 6. Quantity of the geoscientific data compiled in the T-JAM expert database (jan 2011)

Table name	Hungary	Slovenia	Together
General data	792	404	**1196**
Drilling purpose	792	439	**1231**
Water use	792	427	**1219**
Utilization parameters	148	293	**441**
Water temperature at WHD	194	232	**426**
Geology	10379	477	**10856**
Hydrogeology	136	524	**660**
Pumping tests	0	416	**416**
Chemical parameters	14498	10885	**25383**
Bottom hole temperature	310	132	**442**
Core thermal conductivity	0	124	**124**
Surface heat flow density	0	26	**26**
Reference list	0	363	**363**

4. T-JAM boreholes database

One of the goals of the T-JAM project was also additional data compilation which was done by performing new and uniform chemical sampling and hydrogeological testing of 24 thermal wells (12 in Hungary and 12 in Slovenia). These data are incorporated in the public database and freely available. The T-JAM boreholes database is a web based user friendly tool with which the spatial location of the borehole is directly linked to the most relevant geoscientific data. The main advantage of this tool is its possibility to choose the working language between Slovene, Hungarian or English. The public database shows only public and well-specific geoscientific data, whose selected data types are listed in Table 7.

Table 7. T-JAM public database relevant data types

	Javna podatkovna baza T-JAM		Nyilvános adatbázis T-JAM		Public database T-JAM
Splošni podatki	kraj	Általános adatok	település	General data	location
	ime vrtine		fúrás név		borehole name
	širina (stopinje)		szélesség (fok)		width (degrees)
	dolžina (stopinje)		hosszúság (fok)		length (degrees)
	x_SI		x_SI		x_SI
	y_SI		y_SI		y_SI
	z_SI		z_SI		z_SI
	x_eov		x_eov		x_eov
	y_eov		y_eov		y_eov
	z_balti		z_balti		z_balti
	azimut		azimut		azimuth
	naklon		dőlés		dip
	globina vrtanja		fúrás_mélység		drilling depth
	globina cevitve		csövezési_mélység		casing depth
	začetek vrtanja		fúrás_kezdet		drilling start
	konec vrtanja		fúrás_vég		drilling end
	namen vrtanja		fúrás cél		drilling purpose
	uporaba termalne vode		vízhasználat		water use
	vrh perforiranih cevi		szűrő tető		screen top
	dno perforiranih cevi		szűrő talp		screen bottom
	uporabnik objekta		objektum menedzser		object manager
	status objekta		objektum állapot		object status
	opomba		megjegyzés		comment
Geologija	od	Földtan	tól	Geology	from
	do		ig		to
	geološki indeks		földtan index		geological index
	formacija		formáció		formation
	opis litologije		litológiai_leírás		lithology description
	starost		kor		age
	facies		fácies		facies
	litologija od		litológia tól		lithology from
	litologija do		litológia ig		lithology to
	litologija		litológia		lithology
	opomba		megjegyzés		comment

Hidrogeologija	litostratigrafija vodonosnika	Hidrogeológia	vízadó litosztratigráfia	Hydrogeology	aquifer lithostratigraphy
	tip vodonosnika (poroznost)		vízadó típusa (porozitás)		aquifer type (porosity)
	tip vodonosnika (Hochstein)		vízadó típusa (Hochstein)		aquifer type (Hochstein)
	temperatura vode na ustju vrtine		Kifolyási hőmérséklet a kútfejnél		outflow temperature at wellhead
	datum meritve temperature		mérés időpontja		temperature mesurement date
	opomba		megjegyzés		comment
Kemija	analizni laboratorij	Kémiai	elemző laboratórium	Chemistry	laboratory
	datum vzorčenja		dátum		sampling date
	datum kemične analize		dátum		analysis date
	kemijski parameter		kémiai paraméter		chemical parameter
	vrednost		érték		value
	opomba		megjegyzés		comment
Literatura	signatura vira	Hivatkozás	jel (jelentés archív száma)	Reference	signature (archive No of report)
	avtor		szerző		author
	leto		év		year
	naslov		cím		title
	kategorija		kategória		category
	organizacija		intézet		institution
BHT	globina	BHT	mélység	BHT	depth
	BHT temperatura na dnu vrtine		BHT hőmérséklet		BHT temperature

The amount of the available data is given in Table 8, which shows that most of the data is connected to the geology of the captured aquifers and the geochemical properties of thermal water.

Table 8. Quantity of the geoscientific data compiled in the web-based T-JAM database (jan 2011)

Table name	Hungary	Slovenia	Together
General data	**158**	**99**	**257**
Drilling purpose	**158**	**103**	**261**
Water use	**158**	**123**	**281**
Geology	**2606**	**477**	**3083**
Hydrogeology	**136**	**80**	**216**
Chemical parameters	**4735**	**3878**	**8613**
Bottom hole temperature	**179**	**0**	**179**
Reference list for chemistry	**0**	**14**	**14**

The main aim of the GIS web-based application »T-JAM boreholes database« is viewing the public data of boreholes across the whole T-JAM project area. Data were selected from the T-JAM expert database and transferred to a new SQL database of boreholes. Figure 2 shows the relations among different tables in the SQL database.

The web application enables querying among the data of the selected borehole or group of boreholes, measuring distances between them, zooming out, zooming in and to pan around the map. It also shows a map scale at all times and copies out coordinates according to the mouse position on the screen at a temporary view on the map.

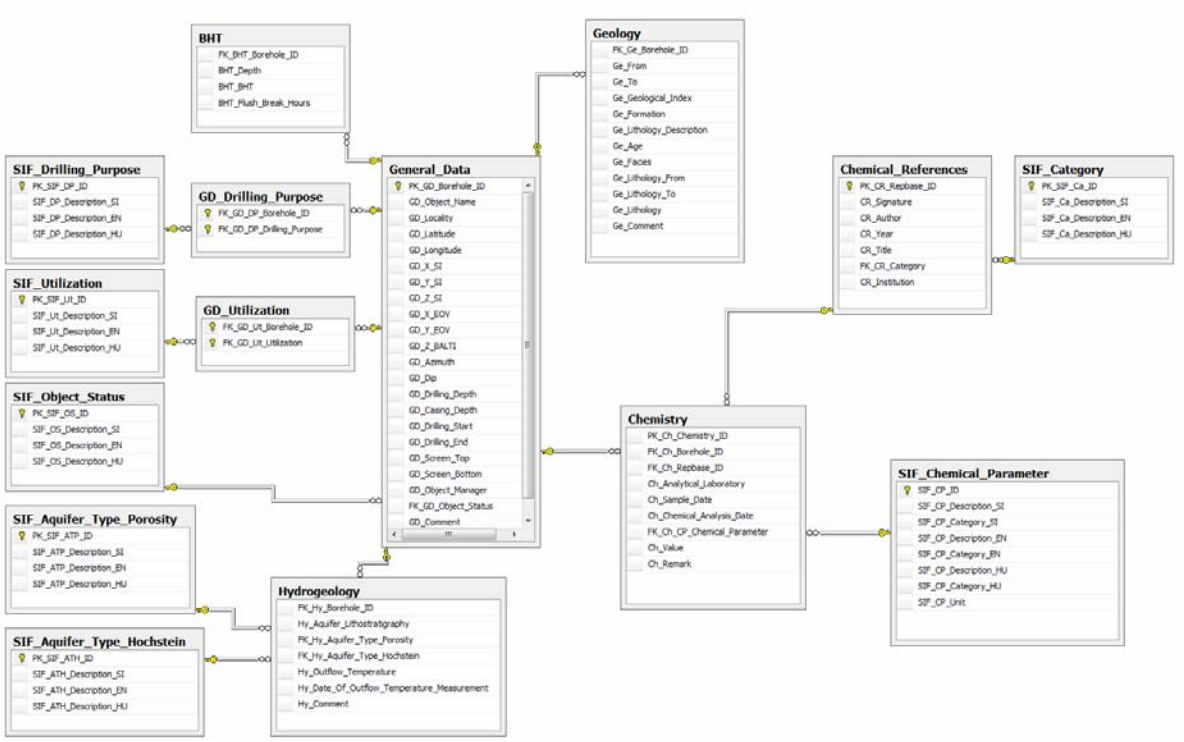

Fig. 2. Structure of the T-JAM boreholes database (SQL) available at http://akvamarin.geo-zs.si/t-jam_boreholes

5. Basic description of the web application

5.1 System architecture

The concept of the web application system architecture is based on the ArcGIS program environment.

The system architecture consists of three main interrelated components:

- Business Logic Tier – it is needed to run services and process requests and responses. When a request is send, it is first handled by the Web server, passed through one of the connectors to be forward to the ArcGIS Application Server, which in turn dispatches the request to an ArcGIS Spatial Server for processing.
- The Presentation Tier – it is a group of clients (HTML Viewer, Java Viewer, ArcExplorer, ect.). For users to access the view and manipulate with the geographic data.
- Data Tier – it consists of the data sources available for use in the ArcGIS Server.

Description of the web application working process:

- application is available on: http://akvamarin.geo-zs.si/t-jam_boreholes
- all spatial data is gathered at the Geological Information Centre at the Geological Survey of Slovenia
- the users can access the data through the web application.

5.1.1 Technical system characteristics

Hardware

- Processor: Intel Xeon CPU E5520 @ 2.27GHz
- RAM: 2 GB
- Hard Disk: 1000 GB

Software

- Operating system Windows Server 2008 R2 Standard (x64) SP0
- Internet Information Services 7
- ESRI ArcGIS Server 9.3 SP1
- SQL Server 2008

5.1.2 Users organization

The web application »T-JAM borehole database« allows all users to access freely to the public data on the presented boreholes and their additional usage.

5.1.3 Contents

The web application consists of:

- T-JAM borehole database (SQL Server RDBM);
- T-JAM borehole spatial database;
- Spatial databases of other spatial data;
- Web client (viewer);
- Available in three languages: Slovene, Hungarian, English.

5.2 Functionality of the web application

5.2.1 Specification of the applied databases

The databases are owned by the GeoZS (SLO) and MAFI (HU) or they contain some freely accessible public data. The data covers the area of the T-JAM project, while the metadata description is available on the web application. Data are stored as vector (ESRI Shapefile) or raster (ESRI/ArcInfo Grid) format:

- Vector datasets:
  - geographic location of boreholes – point layer
  - project area – polygon layer
  - topographical layers (hydro, infra, settlements, country border) – line and point layers.
- Raster datasets:
  - Digital elevation model (SRTM) – hillshade.
- Database:
  - T-JAM borehole database (SQL Server RDBM).

5.2.2 Specification of the application functionality

The web application consists of 4 modules:

- Central GIS database,
- Procedures for data transformation and data import/export,
- Safety access system,
- Web application of spatial data.

5.2.3 Central GIS database

The primary storage place of the spatial data is the GeoZS server; the attribute data is stored in SQL Server RDBM.

5.2.4 Procedures for data transformation and data import/export

The basic starting points for the data transformation, import and export:

- All data is produced or collected in standard GIS formats,
- Input data for GIS database is stored in two different formats:
  - Data in vector format: shape file;
  - Data in raster format: grid.
- For the administrator data is prepared in a way to import them directly or via standard procedures into the database,
- The procedures of the data transformation, import and export are used by GeoZS data manager,

- The data manager is responsible for metadata descriptions.

5.2.5 Safety access system

The system safety access defines the usage and access rights for the application, modules, functions or data (metadata) for a single user or a group of users. The T-JAM borehole database is public therefore no limited rights are defined.

5.2.6 Web application of spatial data

The main aim of the spatial data web application is visualization of the spatial data from different databases. It is an easy and effective tool which gives information on boreholes and at the same time uses different topographic datasets for spatial orientation. It is designed for people who are using the borehole data for their work.

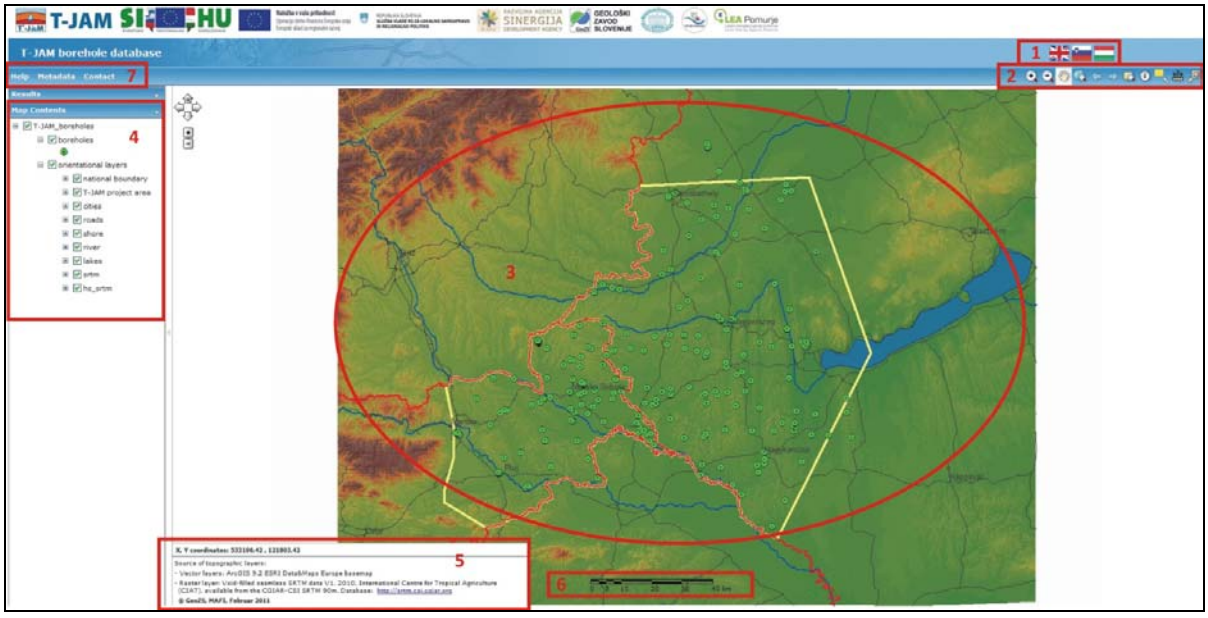

Fig. 3. The divisions of the web application

The web application is freely accessible at: http://akvamarin.geo-zs.si/t-jam_boreholes .

The web application is divided into 7 divisions/parts (Figure 3):

1. Language selection
2. Toolbar
3. Main display window
4. List of contents (data layers)
5. Comment and temporal coordinates review
6. Map scale
7. Help and Metadata description.

The user can easily review a particular spatial location. Moving around the map is easy using functions such as zoom in, zoom out, pan and magnifier. The user can access to the following

data on boreholes: borehole metadata, geology, hydrogeology, geochemistry and BHT. In the top part of the web application there are logos of all project partners and hyperlinks to their websites. Table 9 shows the main functionalities of the web application.

Table 9. Web application functionalities

Zoom In	Obtains a close-up view of an area of the map with a mouse click or drawing rectangular across a map area
Zoom out	Obtains a draw-back view of an area of the map with a mouse click or drawing rectangular across a map area.
Pan	Moves the map back and forth, up and down. User clicks on the map, and while holding mouse button moves around the map. New view keeps the scale.
Full extent	Zooms out to the furthest extent of the map.
Back extent	Zooms the last view in the view window.
Next extent	Zooms the next view in the view window.
Magnifier	It allows up too 10x zooming in of a small area of the map in a new window, while still viewing the main map.
Identify a point	Retrieves information about a particular map object. Attributes open in a new window.
Identify an area	Retrieves information about a group of map objects. Attributes open in a new window.
Measure	Measures the distance. There are 3 possibilities: 1. With a mouse click on the map, we retrieve coordinates of temporal location. 2. With a mouse we drag a line and its length will be displayed. With double-click we finish sketch. 3. With a mouse we draw a polygon and its area will be displayed. With double-click we finish sketch.
Toggle overview map	View the overview map.
Metadata	Metadata description is shown (source of active layer, in this case source of boreholes)
Help	Opens a manual for web application usage.
Map scale	Shows temporal map scale.
Map contents	List of all data layers. User decides which layers will be visible.
Results	List of all selected objects (boreholes) on the map and connection to their attribute data.

5.2.7 Identify a point/an area

The tools enable viewing of the borehole data in a table format. In this web application different queries can be performed only on the borehole layer. The user can choose a particular borehole or a group of boreholes (Fig. 4). The selected boreholes are displayed in the »Result« window, where by choosing »Show data« we can access to the attributes of the selected boreholes.

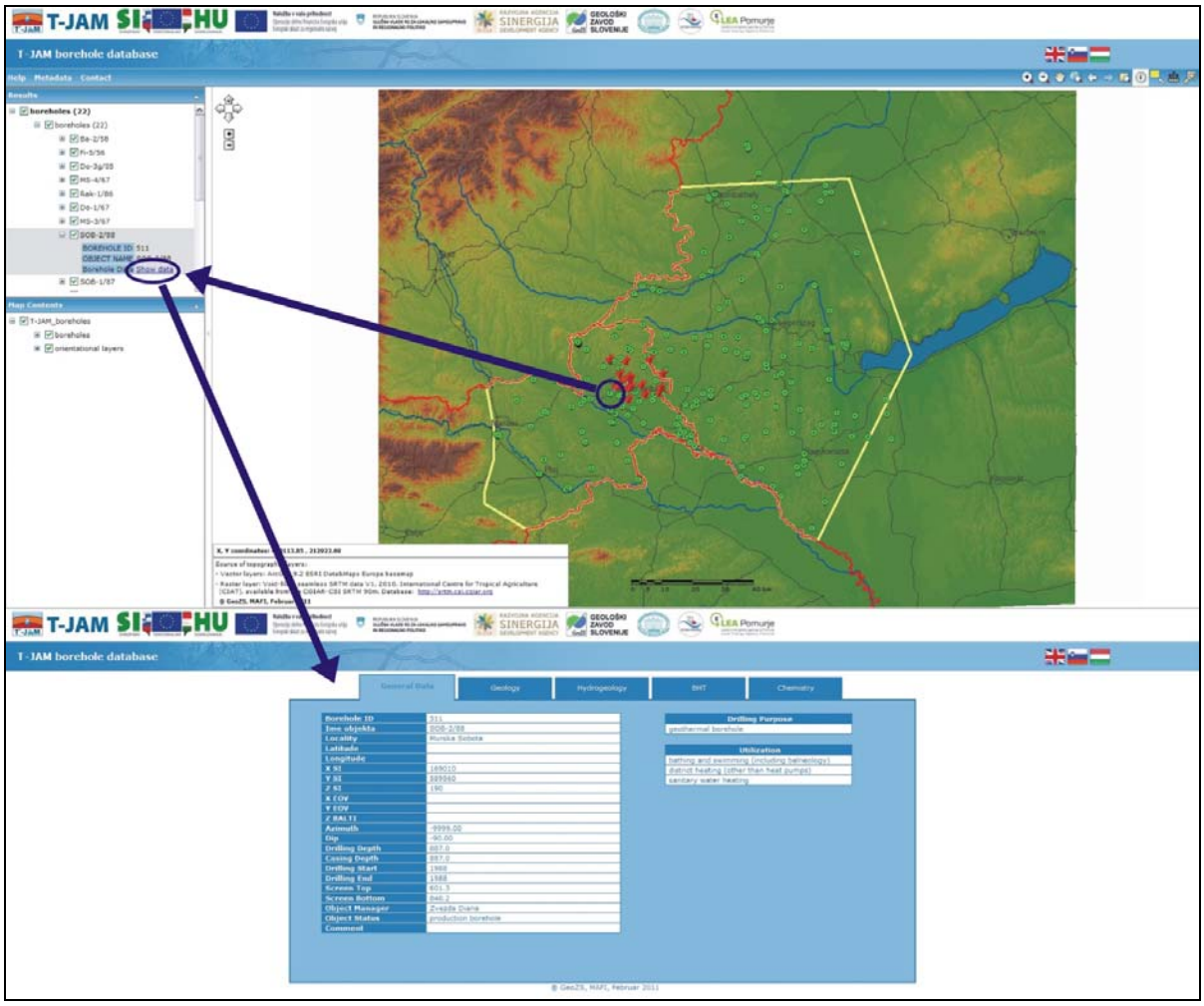

Fig. 4. Usage of a tool »Identify an area«

6. Conclusions

The T-JAM boreholes database, available at http://akvamarin.geo-zs.si/t-jam_boreholes, stores and presents all the available data on boreholes location and their basic geological, hydrogeological, geochemical and geothermal characteristics. The web application tool is designed to provide reliable and useful information for different stakeholders, from the general public interested in the research results to the present and potential geothermal energy users, as well as to the different management authorities.

A detailed look at the data stored and presented in the T-JAM database can help you to find out what is the current knowledge on the thermal water properties and captured aquifers in the area of interest. The contained data was collected by many experts and were re-interpreted for the need of the T-JAM project.

Therefore the data represents valuable information based on which more realistic expectations of the potential future investors / geothermal energy users can be fulfilled. By looking at the database data the (potential) users can get more clear ideas on the possible exploitation characteristics of different aquifers on various locations. As an example: if a producing well exhibits water temperature of 50˚C, it is rather unrealistic to expect that a new nearby well which will capture the same aquifer and will be made with similar technology will produce water of 90˚C. Besides, the data may serve to other stakeholders for the needs of different thermal water utilization and development schemes and studies.

The presented data still needs to be used carefully for further interpretation. Some precautions are needed as the data sources and their reliability are various, which can lead to some misinterpretation if not enough hydrogeological knowledge is applied to the data evaluation.