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The Database of Geothermal Fluids in Switzerland on Google Earth

Romain Sonney, François-D. Vuataz and Stéphane Cattin

Centre for Geothermal Research – CREGE, University of Neuchâtel, Switzerland

romain.sonney@crege.ch

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ABSTRACT

The database BDFGeotherm, containing physical, chemical and hydrogeological information on more than 200 deep fluids from 84 sites in Switzerland and some neighbouring regions, was first compiled on ACCESS code and was later modified to improve its availability and attractiveness by using Google Earth free software and the CREGE website (www.crege.ch/BDFGeotherm/). BDFGeotherm is a functional tool for various phases of a geothermal project such as exploration, production or fluid re-injection. This database allows gathering existing geothermal data, generally widely dispersed and often difficult to reach, towards a user's friendly tool. Downloading the file "BDFGeotherm.kmz" from the CREGE website makes possible to visualize the 84 geothermal sites from Switzerland and neighbouring areas. Each one is represented with a pinpoint of different colour, for diverse temperature ranges.

A large majority of sites is located in the northern part of the Jura Mountain and in the upper Rhone Valley. General information about water use, geology, flow rate, temperature and mineralization are given in a small window by clicking on the desired pinpoint. Moreover, two links to Internet addresses are available for each site in each window, allowing returning to the CREGE website or providing more details on each sampling point such as: geographical description, reservoir geology, hydraulics, hydrochemistry, isotopes and geothermal parameters. For a limited number of sites, photos and a geological log can be viewed and exported (Sonney et al., 2009).

1. INTRODUCTION

Many data exist on geothermal fluids in Switzerland. These data come from deep boreholes realized either for geological evaluations, geothermal prospects, oil exploration, thermal centres as well as thermal springs and fluids outflow from tunnel-drainage systems. All these data are contained in many papers and reports, often unpublished and not very accessible to potential users of this information.

The objective of this project was to gather the maximum amount of data on deep fluids and to integrate them in a relational database named BDFGeotherm. This database can be useful to all geothermal projects planning to prospect, to produce or to inject fluids at depth, in any geological formations having some potential permeability as well as projects based on the enhanced geothermal systems technology (EGS). This tool will be also used to estimate and forecast the chemical composition of the geothermal fluids. The interest of this database is obvious for the studies related to the risks of mineral deposits or corrosion in boreholes and in surface installations, and also for studies on interactions between rocks and thermal waters (Sonney and Vuataz, 2007).

Geographically, all Switzerland was covered, knowing that the distribution of data is quite heterogeneous (figure 1). Other sites were selected outside Switzerland either because they are located near the border, or they have hot springs, deep boreholes, or similar geological features to areas in Switzerland or they represent an interesting geothermal potential. Geologically, each formation containing groundwater, from the crystalline basement to the Tertiary sediments, was taken into account. Moreover, all the thermal and subthermal springs whose temperature is higher or equal to 15°C, or between 10 and 15°C if production yields are important, were included into this database. The selected parameters concern the following fields: geography, geology, hydrogeology, hydraulics, hydrochemistry and geothermal parameters (Table 1). The structure of the multiparameter and interactive BDFGeotherm database was built with the software Microsoft ACCESS.

Before including BDFGeotherm on line, a CD-Rom of the database (version v1) containing the user's manual was available on request from the authors. This database was not accessible via Internet due to its file size (408 Mb) generating long downloading time. Moreover, the use of BDFGeotherm required the use of functionalities of the Microsoft ACCESS software. For all these reasons, it has been proposed to improve the accessibility and the attractivity of this database by using the Google Earth free software (www.earth.google.com) and the CREGE website (Centre for Geothermal Research). Google Earth is used to visualise general information about the 84 sites in Switzerland and neighbouring areas, whereas the CREGE website is used to compile all data in a SQL format.

2. GEOGRAPHICAL LOCATION OF SITES

In total, 84 geothermal sites, and 212 springs and boreholes are documented. Their location on the Swiss tectonic map shows a concentration of sites in the northeastern part of the Jura range, which is characterized by a high geothermal gradient and a significant heat flow anomaly (> 150 mW/m^2, Rybach et al., 1987), and to a lesser extent in the upper Rhone Valley (figure 1).

The Alpine sites are primarily thermal springs, discharging from deep subvertical flow systems in the presence of vertical fractures. The existence of deep faulting tectonics in the Alps allows the infiltrating groundwaters to reach depth of 1 to 4 km (Vuataz, 1997). Strong hydraulic gradients induce thermal water rise along the glacial and alluvial valleys as it can be observed for the upper part of the Rhone Valley.

On the Plateau (Molasse Basin), extending NE-SW and containing the largest lakes of Switzerland, the number of sites is much smaller because of the thick Tertiary Molasse cover. Finally, a number of sites in Germany (5), France (3)

and Italy (6) were selected either because they are located near Swiss hot springs or deep boreholes, have similar geological features or represent a significant geothermal potential (Sonney and Vuataz, 2008).

Table 1: Structure of BDFGeotherm database in (Sonney and Vuataz, 2007).

Table name	*List of fields*
1.Description	Code, site name, country, canton, coordinates X and Y, altitude, type and name of groundwater point, year of realisation, depth, primary and secondary use of fluid.
2.Geology	Code, surface formation, age of surface formation, reservoir formation, age of reservoir formation, regional and local tectonics, lithological log.
3.Hydraulics	Code, flow rate, surface and maximum measured temperature, permeability, production type, static and dynamic water levels.
4.Hydro-chemistry	Code, name and sampling date, simplified and detailed geochemistry type, temperature, conductivity, pH, Ca, Mg, Na, K, Li, Sr, HCO_3, SO_4, Cl, F, SiO_2, TDS (Total Dissolved Solids), ionic balance, TDS variability, comments.
5.Isotope	Code, name and sampling date, ^{18}O, ^{2}H, ^{3}H, residence time, altitude of infiltration, comments.
6.Geothermal parameters	Code, surface and maximum measured temperature, temperature minimum and maximum reservoir, reservoir depth, geothermal gradient and geothermal potential.
7.1.Author	Number of author, author.
7.2.Table-links	Code, number of author and reference.
7.3.Biblio-graphy	Number of reference, reference.

3. IMPLEMENTATION AND USE OF THE DATABASE ON GOOGLE EARTH

The database was modified to improve its accessibility and its attractivity by using the Google Earth free software and the CREGE website. Firstly, the Google earth software was employed to locate geothermal sites in Switzerland and neighbouring regions with pinpoints of different colours representing temperature ranges. To obtain the visualization of sites, the BDFGeotherm database requires to be imported in the software. The needed file named "BDFGeotherm.kmz" can be downloaded in the CREGE website at the address "www.crege.ch/BDFGeotherm/". At the opening of the database in Google Earth, sites with geothermal fluids in Switzerland and neighbouring areas appear on a geographical map with international boundaries and are alphabetically listed in a window on the left side (figure 2).

Five colours were assigned to the pinpoints and correspond to ranges of maximum measured temperatures: >50°C (red), 40-50°C (orange), 30-40 (yellow), 20-30°C (green), and <20°C (black). Visualization of general information about a desired site is possible while clicking only once on a site listed in the window on the left side. A new window will appear in the map showing general information such as: geographical description, geology, hydraulics, hydrochemistry, isotope and geothermal parameters (figure 3).

While clicking twice on a chosen site in the left window, the scale of the map decreases down to a view fixed at 2000 m of elevation, which can be modified by users in the properties of the pinpoint. A new window appears where the coordinates of the site, the pinpoint style and the description can also be changed.

Finally, two Internet links are available for each site in each window, which allow returning to the homepage of BDFGeotherm in the CREGE website and providing more details on each sampling point such as: geographical description, reservoir geology, hydraulics, hydrochemistry, isotopes and geothermal parameters.

4. USE OF THE WEB DATABASE

Initially developed under Access, the database of the geothermal fluids in Switzerland was transposed using Internet technologies. Presently, the data can be consulted by locality. The access to the data will be probably enriched by searching sites from key parameters.

The homepage of this database is available on the CREGE website. On this homepage, the final report, two publications and the database file can be downloaded. Moreover, a dropdown list allows choosing a site in an alphabetical list.

While clicking on a desired site, for example Lavey-les-Bains in Switzerland, general information about the site description and the geology are given with a photo of the site. At the bottom of this window, a frame indicates the presence of 13 sampling points and 7 geological logs of wells (figure 4).

While selecting one of the sampling points as the example of the P600 borehole, a new window opens at the bottom with detailed information about coordinates of the sampling point, elevation, hydrochemistry, hydraulics, isotopes and geothermal parameters. From this window, it is also possible to change the sampling point or to search for another site in BDFGeotherm web database (figure 4).

5. CONCLUSION

Changes brought to the BDFGeotherm database allow improving its accessibility and its attractivity using Google Earth and the CREGE website, and allow solving problems from long time downloading. The use of the database was summarized in this paper and more details are available from the CREGE website.

At this time, general information about 84 geothermal sites for more than 200 deep fluids in Switzerland and neighbouring areas can be visualised. However, there exist other sites with geothermal fluids which are not implemented because data are not available or confidential. Moreover, new geothermal projects in Switzerland are in progress and therefore, new sites will be added in the database in the future.

ACKNOWLEDGMENTS

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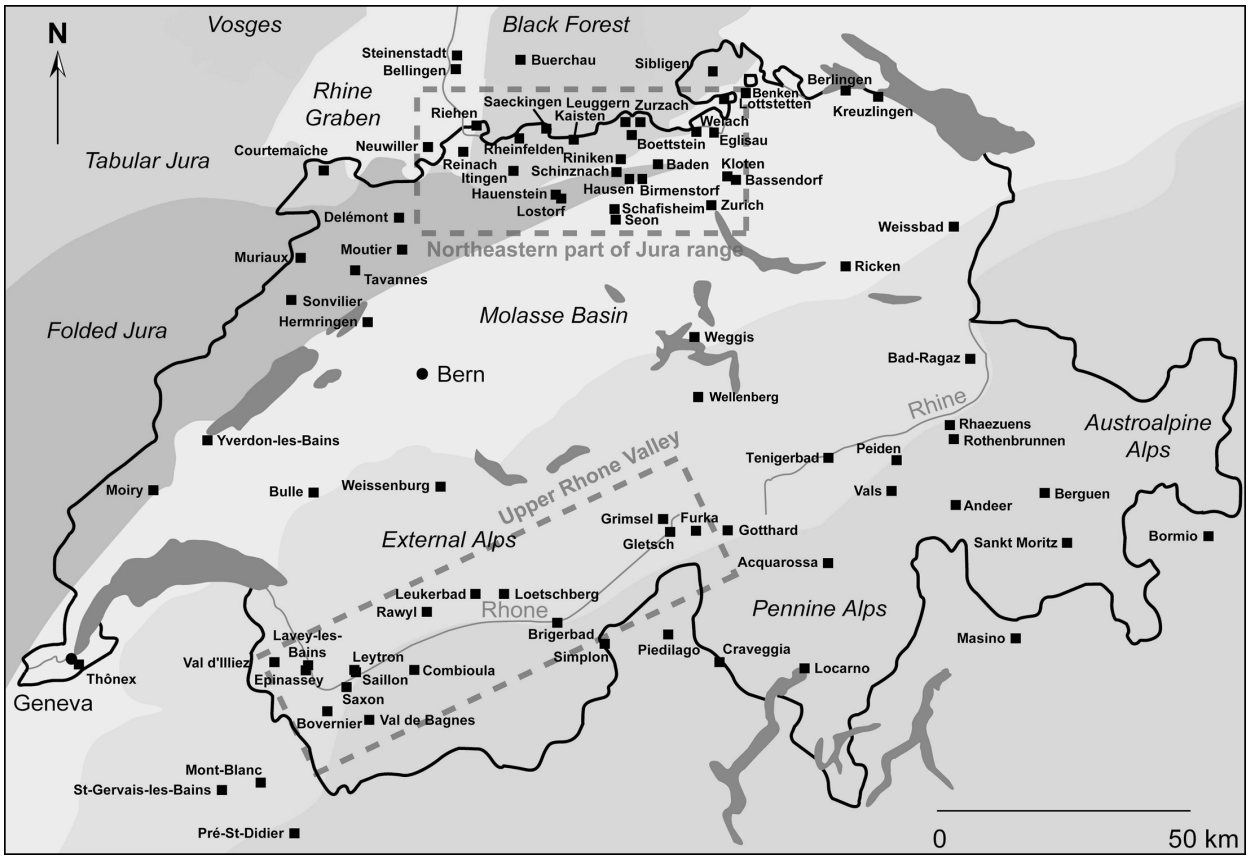

Figure 1: Locations of geothermal sites included in BDFGeotherm. The shaded areas correspond to the main tectonic units of Switzerland (Sonney and Vuataz, 2008).

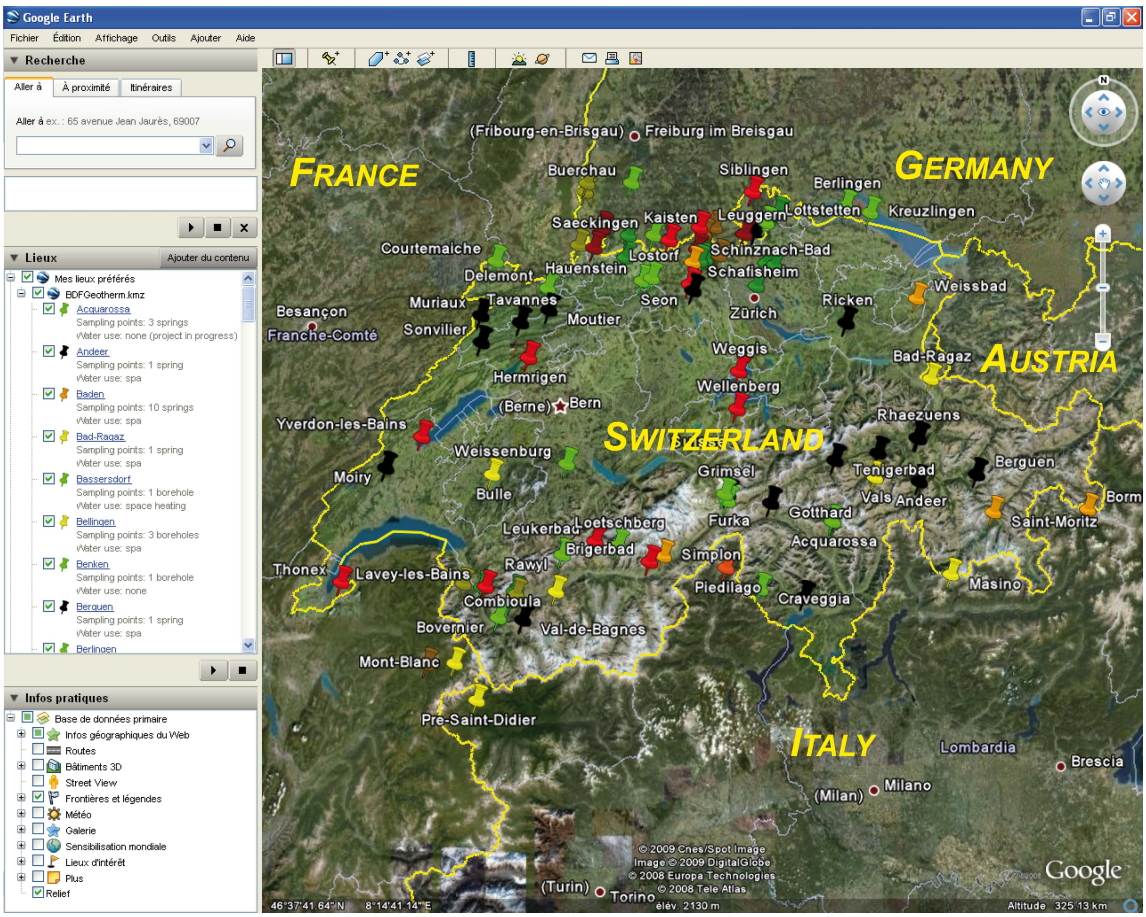

Figure 2: View of all the geothermal sites implemented in the Google Earth free software. Assigned colours to the pinpoints correspond to ranges of maximum measured temperatures: >50°C (red), 40-50°C (orange) 30-40°C (yellow), 20-30°C (green), and <20°C (black) (Sonney and Vuataz, 2009).

Figure 3: Example of Lavey-les-Bains geothermal site implemented in the Google Earth free software. Visualization of general information about this site is possible while clicking only once on the red pinpoint. Two Internet links allow returning to the homepage of BDFGeotherm in the CREGE website.

BDFGeotherm – General information on Lavey-les-Bains

Site description

Country	Switzerland
Canton/Province	Vaud
Primary use	Thermal usage
Secondary use	Building heating

Geology

Surface formation	Alluvial deposits
Age of surface formation	Quaternary
Reservoir formation	Gneiss
Age of reservoir formation	Hercynian
Geological setting	Aiguilles Rouges Massif

Lavey-les-Bains has 13 sampling points and 7 geological logs are available (*)

P600 (LAVEY-P600)*
P201 (LAVEY-P201)*
P205 (LAVEY-P205)*
P11 (LAVEY-P11)*
P12 (LAVEY-P12)*
P13 (LAVEY-P13)*
P14 (LAVEY-P14)*
S7 (LAVEY-S7)
S8 (LAVEY-S8)
S9 (LAVEY-S9)
Q8 (LAVEY-Q8)
AP (LAVEY-AP)
S10 (LAVEY-S10)

Search another site in BDFGeotherm web database

Lavey-les-Bains

Site: Lavey-les-Bains
Sampling point: P600
Sample name: LAVEY-P600

Description
Samplig point type: Borehole
X-coord: 568'080
Y-coord: 116'482
Elevation: 431.75 m amsl
Depth: 517 m

Hydrochemistry
Sampling date: 12.09.2006
Geochemical type: Na-SO_4>Cl
Temperature: 64.0 °C
Electrical conductivity: 1767 µS/cm
pH: 7.7
Cations (mg/l)
Li: 3.7
Na: 376
K: 11.5
Mg: 1.51
Ca: 56.7
Sr: *no data*
Anions (mg/l)
F: 6.1
Cl: 242
SO_4: 577
HCO_3: 87.4
Undissociated (mg/l)
SiO_2: 65.7

TDS: 1435 mg/l
Ionic balance: -1.23 %

Hydraulics
Flow rate: 20.00 l/s
Surface temperature: 65.0 °C
Max. measured temp.: 72.0 °C
Hydraul. conduct.: 1.0 x 10^{-3} m/s
Exploitation mode: Pumping

Isotopes
Sampling date: 12.09.2006
$\delta^{18}O$: -13.15 ‰
D: -97.10 ‰
^{3}H: 1.0 TU
^{14}C: *no data*
Resid. time: *no data*
Infiltration area: 1850 m amsl

Geothermal parameters
Min. reservoir temp.: 100 °C
Max. reservoir temp.: 110 °C
Reservoir depth: -2500 m amsl
Geoth. gradient: *no data*
Geoth. potential: 4600 kW_{th}

Geological log

Figure 4: Example of Lavey-les-Bains: view of the main information page for the P600 borehole.