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Plenary Presentations

Wednesday, May 8, 2013 - Conference Room

Chaiman: *István Fórizs*

Plenary section	10.00 - 10.30	József Tóth University of Alberta	*Geothermal phenomena in the context of gravity-driven basinal groundwater flow*
	10.30 - 11.00	László Rybach ETH Zurich	*Innovative energetic use of shallow and deep groundwaters: Examples from China & Switzerland*
	11.00 - 11.30	Judit Mádl-Szőnyi ELTE Budapest	*Geothermal potential of Hungary: what can we learn from the flow-system approach?*

Plenary Events

Thursday, May 9, 2013 - Conference Room

Chaiman: *József Tóth / Petar Milanovic*

Brand-new technology section	9.30 - 9.45	Bajcsi P., Bozsó T., Bozsó R., Molnár G., Tábor V.	*New well-completion and rework technology by laser*
	9.45 - 10.00	Czinkota I., M. Tóth T., Kovács B., Schubert F., Szanyi J., Bozsó G.	*Analysis of the Thermal Decomposition of Alkaline-Earth Sulphates*
	13.00 - 14.30	*Press conference*	

Thursday, May 9, 2013 - Conference Room

Chaiman: *Tamás Madarász / Andrzej J. Witkowski*

14.30 - 16.00

Round table discussion on Education in Hydrogeology

Wednesday, May 8, 2013 - Conference Room
Chaiman: Gyula Dankó / Marco Petitta

Section	Time	Author(s)	Title
Origin of thermal waters: hydrogeology, chemistry, age, isotopes	14.00 - 14.15	Fabbri P.	Characteristics of the geothermal Euganean Basin (Veneto region, NE Italy)
	14.15 - 14.30	Stevanovic Z., Dulic I., Duncic M.	Some experiences in tapping deep thermal waters of Triassic karstic aquifer in Pannonian basin of Serbia
	14.30 - 14.45	Borović S., Marković T., Larva O.	Hydrogeological and hydrochemical characteristics of Daruvar geothermal aquifer (Croatia)
	14.45 - 15.00	Kuz'mina E. A., Didenkov Y., Veshcheva S.	Genesis of thermal waters in the Baikal Rift System (based on physical and chemical simulation)
	15.00 - 15.15	QUESTIONS	
	15.15 - 15.30	Weyer K. U., Ellis J. C.	Groundwater dynamics of thermal areas and geysers in Yellowstone National Park
	15.30 - 15.45	Varsányi I.	How does the chemical composition of water relate to the hydraulic continuity in the Great Hungarian Plain
	15.45 - 16.00	Erőss A., Mádl-Szőnyi J., HorváthÁ.	Radionuclides as mixing indicators of thermal waters
	16.00 - 16.15	Grassi S., Doveri M., Ellero A., Palmieri F., Vaselli L.*	Study of the Montecatini and Monsummano Terme low temperature geothermal prospects (Tuscany- Central Italy)
	16.15 - 16.30	QUESTIONS	

Wednesday, May 8, 2013 - Small Conference Room
Chaiman: Péter Szűcs / Andrzej Kowalczyk

Section	Time	Author(s)	Title
Others	14.00 - 14.15	Szőcs T., Tóth Gy., Rotár-Szalkai Á., Gál N., Nádor A., Zilahi Sebess L., Gulyás Á., Merényi L.	Combined hydrogeological-geophysical surveys in geothermal resource evaluations and sustainable thermal water exploitation, Hungary
	14.15 - 14.30	Kovács B., Kolencsik-Tóth A.	Evaluation of groundwater-surface water interaction along the Tisa river
	14.30 - 14.45	Bernáth Gy.	Calculating measured pressure values to different depths in the case of producing and non-producing wells
	14.45 - 15.00	Madarász T., Szűcs P., Kovács B., Lénárt L.	Well aHead - a source of fresh thoughts in groundwater management
	15.00 - 15.15	QUESTIONS	
	15.15 - 15.30	Kowalczyk A. Sitek S., Witkowski A. J.	Impact of theTarnowskie Gory urbanised area (Poland) on groundwater contamination by chlorinated hydrocarbons
Renewable electricity supply: geothermal power plant	15.30 - 15.45	Dankó Gy., Bőthi Z.	Optimization of geothermal system for sustainable power generation
	15.45 - 16.00	Cerutti P., Ducci, D., Fabbri P., Fidelibus M. D., La Vigna F., Lo Russo S., Manzella A., Mazza R., Polemio M., Sottani A.	Sustainable use of geothermal resources in Italy: first inventory of data, applications and case studies
	16.00 - 16.15	QUESTIONS	

Thursday, May 9, 2013 – Conference Room
Chaiman: László Rybach / Balázs Kovács

Section	Time	Author(s)	Title
Advanced modelling: flow and heat	10.30- 10.45	Hokr M., Rálek P., Balvín A., Straka T.	Thermal interaction of rock and water controlled by temperature variations in a tunnel
	10.45 - 11.00	Kaiser B. O., Cacace M. , Scheck-Wenderoth M.	Three-dimensional convection within the Northeast German Basin
	11.00- 11.15	Pola M., Fabbri P., Piccinini L., Zampieri D.	A new hydrothermal conceptual and numerical model of the Euganean Geothermal System - NE Italy
	11.15 - 11.30	Weyer K. U., Ellis J. C.	Effect of gravitational forces on thermal groundwater flow
	11.30 - 11.45	QUESTIONS	
	11.45 - 12.00	Szűcs P., Székely F., Zákányi B.	Different modeling methods to simulate groundwater flow to multi screen wells
	12.00 - 12.15	Merényi L.	Simulation of thermal interaction between groundwater and borehole heat exchanger
	12.15 - 12.30	Kovács A., Rotár-Szalkai Á.	A coupled geothermal model of the Alpokalja area, Hungary
	12.30 - 12.45	Lux M.	Hydrodynamic modelling and geothermal potential in an overpressured basin
	12.45 – 13.00	Gáspár E., Tóth Gy., Švasta J., Remsik A., Bodis D., Černák R.	Hydraulic and Geothermal modelling on the Komarno-Šturovo Pilot Area of the TRANSENERGY project

Thursday, May 9, 2013 – Small Conference Room
Chaiman:Judit Mádl-Szőnyi / Zoran P. Stevanovic

Section	Time	Author(s)	Title
Drilling technologies, well completion and hydrodynamic investigations	10.30- 10.45	Mező Gy., Andrássy M., Korpai F., Dankó Gy.	Cross-hole test in geothermal wells
Direct geothermal energy use: heating, balneology, etc.	10.45 - 11.00	Erőss A., Zsemle F., Pataki L., Csordás J., Zsuppán K., Pulay E.	Heat potential evaluation of effluent and used thermal waters in Budapest, Hungary
Sustainable thermal water reservoir management	11.00- 11.15	Buday T., Bódi E.	Effects of approaches generating different solid models on hydrodynamic models based on the case study of Hajdúszoboszló, East-Hungary
	11.15 - 11.30	Novák P., Hokr M.., Lachman V., Štrunc J., Hladký R.	Significance of a water bearing fracture for underground thermal energy storage - a model of middle scale laboratory experiment
	11.30 - 11.45	QUESTIONS	
	11.45 - 12.00	Piscopo V., Baiocchi A., Lotti F.	Hydrogeological approach in sustainable management of thermal waters: two examples from Italian volcanic aquifers
	12.00 - 12.15	Petitta M., Brunetti E., Carucci V., Sbarbati C.	Groundwater flow and geochemical modeling of the Acque Albule thermal basin (Central Italy): influences of human exploitation on flowpath and thermal resource availability
	12.15 - 12.30	Rotár-Szalkai Á., Gál N., Szőcs T., Tóth Gy., Lapanje A., Cernak R., Scubert G., Götzl G.	Geothermal reservoirs in the western part of the Pannonian Basin
	12.30 - 12.45	QUESTIONS	

Poster section

Wednesday., May 8, 2013 - Conference Room *Chaiman: Ágnes Tahy / Tamara Marković*	
Fejes Z., Szűcs P.	Potential thermal water resources in Szerencs area
Mikita V., Kovács B., Szanyi J., Virág M., Kiss M.	Geothermal conditions of the Szabolcs-Szatmár-Bereg and Satu Mare transboundary region
Székely F.	Evaluation of packer tests in deep open boreholes
Mádl-Szőnyi J., Simon Sz.	Hydraulic framework of sustainable thermal water production from a gravitational-overpressured system on the example of Duna-Tisza Interfluve, Hungary
Kompár L., Szűcs P., Palcsu L., Deák J, Dobos E.	Isotope measurements at different sites to estimate the recharge at the Danube-Tisza Interfluves
Szongoth G., Buránszki J.	Inspection of thermal wells in Szentes area
Ötvös V., Erhardt I., Czauner B., Erőss A., Simon Sz., Mádl-Szőnyi J.	Hydraulic evaluation of the flow systems of Buda Thermal Karst, Budapest, Hungary
Zákányi B., Szűcs P., Tóth M.	Sensitivity of DNAPL transport simulations concerning the relative permeability data
Kun É., Székvölgyi K., Gondárné Sőregi K., Gondár K.	Inferences from 3D modelling of thermal karstic reservoir (SW Bükk Mountain)
Bálint A., Kiss S.	Development plan of the Szentes geothermal field based on hydrodynamic modeling
Madarasi A.	Electrical conductors in basement - a magnetotelluric insight into the geothermal potential
Pulay E., Mádl-Szőnyi J.	Hydraulic and thermal evaluation of Gödöllő Area, Hungary, for geothermal purposes
Czinkota I, Szanyi J, Kovács B, Vadkerti Zs., Papp M.	The effect of the thermal water aeration and water-rock interaction
Lénárt L., Szegediné Darabos E.	Hydrodynamics of cold and warm karst systems in the Bükk region
Kis B. M., Kármán K., Baciu C.	Origin of mineral water springs from Rodna-Bârgău area (Eastern Carpathians, Romania)
Mádl-Szőnyi J., Virág M., Zsemle F.	Hydrogeological establishment of the installation of water based geothermal heat pump systems in Budapest, Hungary

Geothermal phenomena in the context of gravity-driven basinal groundwater flow

József Tóth

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Gravity-driven groundwater flow systems function as subsurface conveyor belts in topographic basins. They pick up, move and deliver fluids, gases, solutes, colloids, particulate matter and heat from loading sites in recharge areas and on their way to the discharge areas. Flow systems of various horizontal and vertical extents are organized into hierarchically nested complex patterns controlled by the configuration of the water table's relief and modified by the rock framework's heterogeneities. The systems are ubiquitous and act simultaneously on broad ranges of the spatial and temporal scales of measurement. Their universal geologic agency is manifest by a great number of different and widely disparate natural processes and phenomena, several of which are associated with geothermal heat flow. The understanding of geothermal phenomena in the context of basinal flow systems requires, therefore, a general familiarity with the umbrella "theory of regional groundwater flow" which, in turn, comprises two component theories, namely: 1. "The hydraulics of basin-scale groundwater flow systems" and, 2. "The geologic agency of basin-scale groundwJater flow- systems." The talk's structure is based on the above view.

The *Introduction* reviews the evolutionary history, principal aspects and current state of the art of the theory and its practical applications. In Section 2, the *hydraulics of basin-scale groundwater flow systems*, the progressive historical stages of the analysis of flow patterns and fluid dynamic parameters are presented, while Section 3, the *geologic agency of basin-scale groundwater flow*, exemplifies different natural processes and phenomena mediated by moving groundwater. Section 4, *geothermal phenomena in the context of gravity flow of groundwater*, focusses on geothermal effects of groundwater flow and presents examples from the very first theoretical models through case studies of thermal springs and wells, hypogenic karst development, and petroleum accumulations. The *Conclusion* conveys the author's conviction that geothermal studies conducted for whatever purpose can not be complete without consideration of the area's groundwater flow regime.

Conclusions

Applying the velocity potential of continuum mechanics to geothermal flow returns unsatisfactory results which do not adhere to the physical principles of flow in porous media. Geothermal water migrates as part of gravitational groundwater flow systems. Convection cells do not exist within gravitational ground water flow systems.

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Different modeling methods to simulate groundwater flow to multi screen wells

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Introduction

Real pumpage from aquifers is commonly more complex. Heads in aquifers that surround a well are likely to vary along the length of a screen that penetrate the aquifer or has a long horizontal extent (Szucs et al., 2006). Because of this special flow behavior, a simulation program called the drawdown-limited, Multi-Node Well (MNW) Package was developed for MODFLOW (Halford & Hanson 2002). The MNW package enables MODFLOW specialists to simulate wells with short or multiple screens. Multi-node wells can simulate wells that are completed in multiple aquifers or in a single heterogeneous aquifer, hydraulic effect of partially penetrating (see Fig. 1.), and even horizontal wells. The multi-node aspect of the MNW package can enhance model calibration and groundwater simulation opportunities of MODFLOW.

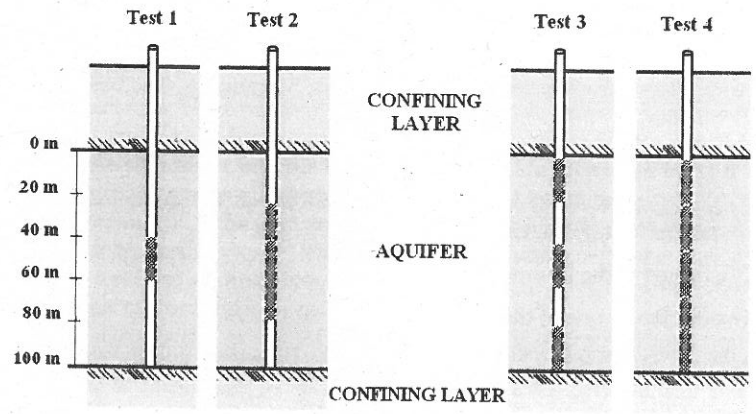

Fig. 1.- Fully (Test 4), partially (Test 1, Test 2) penetrating and multi screen (Test 3) wells for case-study simulation investigations (after Konikow et al. 2009).

An alternate numerical multiscreen well flow simulator FLOW was created and improved by Székely et al. (1996, 2000). The well flow module of FD (finite difference) groundwater flow simulator estimates the well bore drawdown and screen fluxes with the effects of laminar and turbulent skin losses. The point centered FD scheme generates the cell drawdown due to distributed flux W, whereas the additional local drawdown in well bore is calculated for the actual (confined or leaky) flow conditions around the screen(s).

Comparison of different simulation approaches

The case-study comparison study facilitates a specific hydraulic modeling job using different solution methods. Four different tests were carried out to show how the MNW and FLOW packages work concerning the simulation results. Results of calculations are listed in Table 1. The confined simulation model comprises 5 homogeneous horizontal layers with equal parameters as follows:

Thickness: 20 m.

Initial hydraulic head: 0 m.

The hydraulic conductivity: 0.0001 m/s.

Horizontal and vertical anisotropy: 1.

Specific storage: 0.00001 1/m.

Parameters of the model area:

Left bottom corner coordinate is: (0 m, 0 m).

Right uppermost corner coordinate is: (510 m, 510 m).

Grid system used by MODFLOW: 51 rows, 51 columns. The basic grid size: dl = 10 m.

Well data:

A pumping well is located in the middle of the modeled area. The coordinate is: (255 m, 255 m).

The radius of the pumping well is: 0.2 m.

The discharge rate of the pumping well is: -0.1 m^3/s.

The FLOW package uses 50 blocks in both x and y directions and the square blocks have dl = 10.2 m long sides. Thus, the well can be positioned at the common corners of four neighboring blocks as required by the point centered FD schemes or finite element simulators.

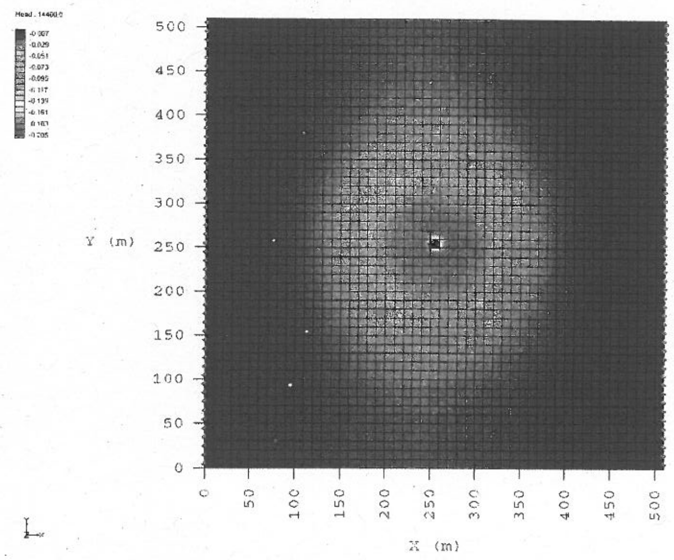

Fig. 2.-The applied grid system with the boundary conditions, the production well in the middle of the model area and drawdown contour lines of Test 3.

To use the MNW package with MODFLOW, the hydrodynamic model of the investigated area was compiled using the Groundwater Modeling System (GMS 7.1) modeling package. The applied grid system with the boundary conditions and the well in the middle can be seen in Fig. 2. Constant head boundary conditions were set on the west and east side of the model area. No flow boundary conditions were set in the north and south side of the model area.

The skin effect can be expressed as the change of hydraulic conductivity (or permeability) around productions wells. The MNW package allows the experts to incorporate the skin effect into the simulations. The skin effect can be pictured as head loss occurring across a cylinder of radius, r_{Skin}, around the investigated well with a finite radius, r_w. The skin zone has a transmissivity T_{Skin}, that differs from the formation transmissivity T. The dimensionless skin coefficient can then be described in terms of a transmissivity contrast (T/T_{Skin}) over the finite difference between r_w and r_{Skin} or by:

$$Skin = \left(\frac{T}{T_{Skin}} - 1\right) ln\left(\frac{r_{Skin}}{r_w}\right). \quad (1)$$

In most cases the Skin is positive. The skin coefficient is equal to zero or negative if T_{Skin} is equal to or greater than T. The additional (+ or -) drawdown ds_{Skin} caused by the skin effect can be calculated as:

$$ds_{Skin} = \frac{Q}{2\pi T} \cdot Skin. \quad (2)$$

Tests 1, 2, 3 and 4 (see Fig. 1) were performed at the same rate of 0.1 m^3/s and demonsrate effect of different screening shemes in the 5-layer-model. In case of Test 1 only one layer was screened. This scheme may involve five different options, as the screen can be installed separately at the top (in layer 1), at the bottom (in layer 5), in the middle (in layer 3), and in layers 2 or 4. In case of Test 2 layers 2, 3 and 4 are screened, whereas layers 1, 3 and 5 are tapped in Test 3. Finally, in case of Test 4 all the five layers are screened simultaneously.

Results and discussion

Results of comparative simulations are summarized in Table 1. Column 4 displays 3D_A data obtained by WT simulation considering 5 model layers and l_{scr} = 20 m long screens represented by line sinks. Column 5 exhibits results of an enhanced 3D_B modeling where each screen is split into 80 sections of l_{scr} = 0.25 m. This segmentation provides a very detailed flux distribution along screens therefore these data are considered as the "true" solution to the test problem analyzed and used as reference values. The last two columns show results of numerical MODFLOW and FLOW simulations with close s data and higher discrepancy in calculated fluxes.

Table 1. Summary of comparative evaluation of well flow simulators.

Tests	Screened layers	Data	3D_A l_{scr}=20 m	3D_B l_{scr}=0.25 m	MODFLOW dl=10 m	FLOW dl=10.2 m
1	1 or 5	s	40.648	39.986	42.087	42.030
	2 or 4		36.608	35.822	39.274	39.212
	3		36.275	35.486	38.950	38.887
2	2-3-4	s	16.409	16.253	16.730	16.730
		Q% 2 & 4	34.578	34.577	34.872	34.001
		Q% 3	30.843	30.846	30.245	31.999
3	1-3-5	s	15.724	15.507	16.305	16.304
		Q% 1 & 5	32.284	32.223	32.071	32.727
		Q% 3	35.432	35.554	35.855	34.547
4	1-2-3-4-5	s	12.053		12.052	12.053

Data for Test 4 (fully penetrated well) confirms good fit among all the drawdown data. The three models resulted in uniform Q% = 20 screen fluxes in this test. For the other tests numerical well bore drawdown data show close overestimation.

This, however, can be reduced through vertical refinement of the 100 m thick flow domain. Thus, by applying 50 model layers and 10 sub-screens (l_{scr} = 2 m) in the upper 20 m thick section the first s value in the last column reduces to 40.226 m. The latter is a close approximation to the 3D_B simulation. Closer inspection of Q% data reveals that the 3D_B fluxes (reference data) are positioned between the two numerical solutions.

Conclusions

The following summary can be made on the obtained results of the present study:

1. Two analytical (3D_A, 3D_B) and two numerical (MODFLOW, FLOW) methods were involved and compared to test their multiaquifer well flow simulation abilities.
2. The obtained results confirmed that the numerical MODFLOW MNW and FLOW packages can provide reliable and accurate simulations even in complex hydraulic situations in multilayer aquifers.
3. In case of multiscreen well flow simulation several modeling techniques are proposed to establish and minimize the approximation error of different origin and range. This may help in finding the optimum solution to simulate flow metering data, contaminant transport and to involve this database into model calibration.

Acknowledgements

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