Journal of Georgian Geophysical Society
Issue (A), Physics of Solid Earth, v. 16a, 2013, pp. 44-51

CREATION NUMERICAL MODEL OF THE TSAISHI GEOTHERMAL REZERVIOR FOR ORGANIZATION OF GEOTHERMAL CIRCULATION SYSTEM

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Abstract

The main aim of the project was to arrange the first geothermal circulation/re_injection system on Tsaishi geothermal filed in Georgia and rehabilitation of heating system of Tsaishi public school, by using environmentally clean, renewable energy source. In order to implement the main aim of the project had been organized the hydrogelogical testing the existing boreholes in order to determine the boreholes' properties and to create a model of aquifer. The digital modelling represents the main steps of calibration and simulation process, which gives the possibility to estimate and study the different scenarios of exploatation and development of precesses.

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1. Introduction

There are five deep wells arranged on a short distance from each other in settlement Tsaishi #4k, #8k and #10t, from where thermal water outpours uselessly or is used by handmade pipes and only a small part of it.

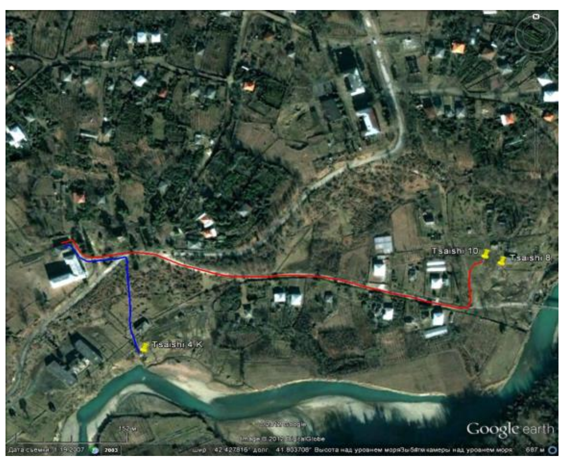

Fig. 1 Project design scheme

Out of existed thermal wells as a result of hydro geological study only two #10t as exploitation and #4k - as injection wells were selected. The geothermal circulation system had been arranged and the heat system of Tsaishi public school building was connected to this system. For more details see the scheme below (Fig. 1). The school had been supplied with thermal water from well 10 (red line on the scheme). After heating of school the used water is transported (blue line) by pipe to Tsaishi 4k well for the reinjection.

2. Hydrodynamic Research Methods

In order to determine the hydrodynamical parameters (coefficient of filtration, permeability, conductivity, debit, temperature, static and dynamic pressure and etc) of main water bearing horizon, which are necessary for digital modeling, should be done field tests of the boreholes according to the standard method (1, 2, 3) using licensed softwares.

As it is already known, two boreholes - #10 and #4k were considered to be used for geothermal circulation system implementation – first one as productive and second – reinjection. Nearby boreholes that are in 20-50 m distance from #10 borehole were used for monitoring. Measurement and registration works were conducted on these boreholes during the entire exploitation season.
Simultaneously, for measurement equipment installation boreholes unit were prepared and afterwards equipment was installed (water pressure, temperature and discharge measurement sensors, atmosphere and neutral gas measurement sensor). Whole debit and the quantity of water utilized by school heating system were measured on #10 borehole. After heat was deprived, water flow was pumped in #4k borehole by using special pump. All parameters of reinjection process were recorded.
Continuous monitoring was organized. Monitoring was continued till the end of the project and separate boreholes hydrodynamic parameters determination was conducted through testing;

3. Determination of hydrodynamic parameters

In order to define hydro dynamic parameters of exploitation and injection boreholes on #4 and #1K injection boreholes experimental testing was conducted.

Special water pressure and temperature measurement device was installed on boreholes that in a frequent mode (once in a minute) was recording data. In order to define boreholes interaction as well as horizon filtration characteristics #4 borehole along with #1 borehole was closed and reopened few times. Example of observed variations sees on pics (Fig. 2, 3).

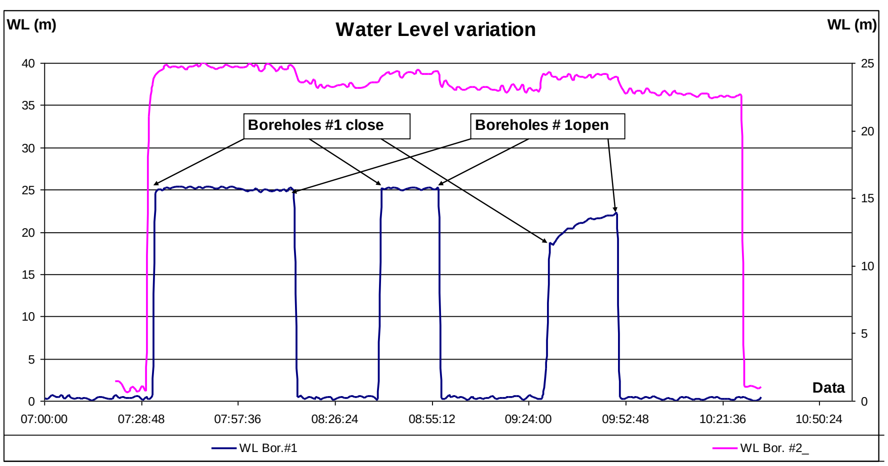

Fig. 2 Water pressure and temperature variation graphics on #4 K regime borehole during experimental testing

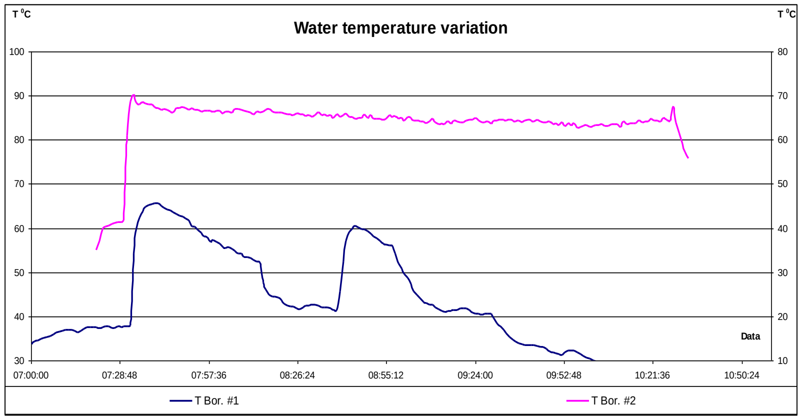

Fig. 3 Water pressure and temperature variation graphics on #1 K regime borehole during experimental testing

Hydrodynamic parameters had been calculated based only on data from #4 borehole (Fig. 4)

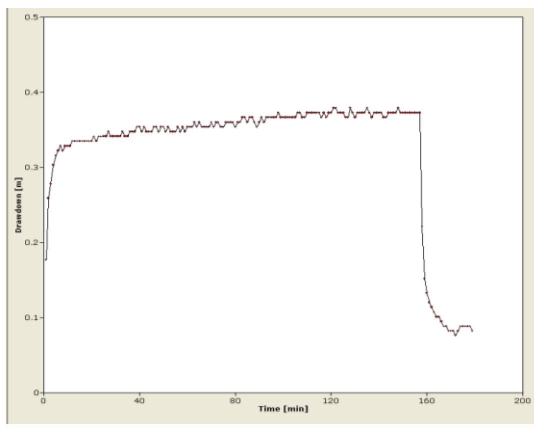

Fig. 4 Water level restoration graphics on a N4 K borehole

Recorded row data during pump test had been processed by the specific programme Aquifertest pro 4.2. (Fig. 5)

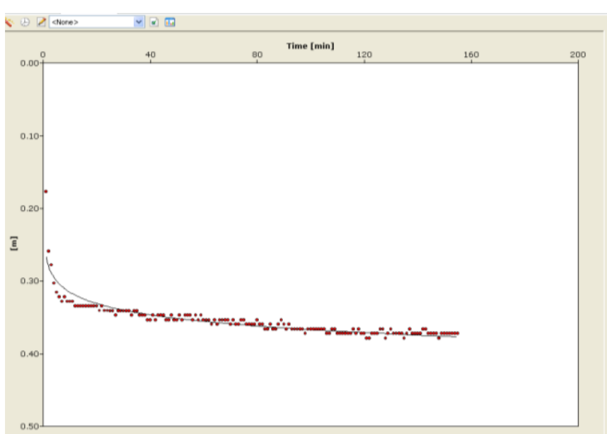

Fig. 5 Water level change logarithmic curve

In order to calculate search options Jacobs method was used. For this aim straight section was selected on a water level fall curve (indications from 15 up to 155) (Fig.6).

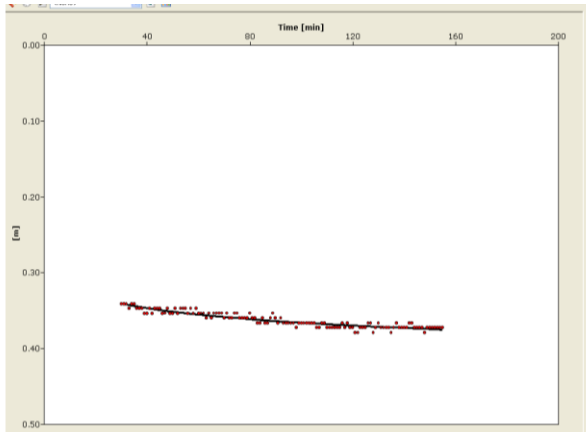

Fig.6. Water level change logarithmic curve for selected section

As given graphic demonstrate, there is complete convergence between calculated and theoretical curves. Water consist horizon hydrodynamic parameters were calculated - distribution of water T=4620 m^2/ during day/night period and water output S=4.18*10-8.

In order to define interdependence of boreholes testing was repeated, during this process # 10 productive borehole was included as well. During testing boreholes were closed an open in sequence and #4 K borehole was observed. As a result a good hydrodynamic connection between boreholes was again demonstrated.

Based on field researche's received data, section's digital modelling and determination of geothermal circulation system efficiency was started.

Eleboration of digital modeling was conducted according to famous methods like (Domenico and Schwartz, 1998; Middlemis, 2000) by using computer program Feflow and was consist of several stages:

4. Research area's boundary conditions definitiona and elaboration of conceptual model

As it was mantioned above, modeling was conducted by using program package Feflow 5.3, that give a possibility to calculate thermal area's three-dimensional model. In addition, environmental three-dimensional geometrical model was intialy prepared by using programs ArcMap 9.2 and ArcView 3.2 a.

Based on existed geological and hydrogeological materials analysis, following conceptual model for Tsaishi hydrothermal basin was eleborated, according to it, water consist layer is formed by cretaceous age limestones. They are about ten different capacity water conductor layer and less water conductor layers. Model's area constitute $23.6*10^6$ m^2 .

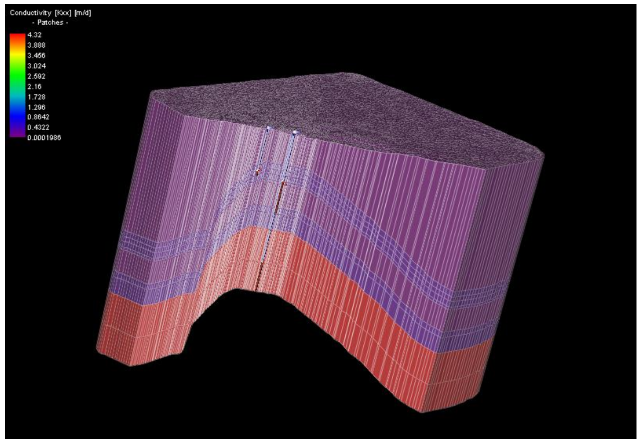

Fig.7. Conceptual models block-scheme elaborated for Tsaishi hydrothermal area.

Water consist horizons filtration coefficient values are presented in the table 2

Table 2

Layer number	Kx,Ky, m/sec	Kz, m/sec
#1,#6	$2.3*10^{-9}$	Kx/10
#2#3#4#5#7#8	$0.024*10^{-4}$	Kx/2
#9#10	$0.5*10^{-4}$	Kx/2

From the table it is evident, that # 1 and #6 are non water conductor layers, #2, #3, #4, #5, #7, #8 are good water conductor layers, thermal water from # 9 and # 10 layres is taken by # 10 borehole.
Basin's piezometric maps, mineralization and thermal profiles indicate on underground water movement regional direction from north-east to south-west. Accordingly, water inflow into aquifer is secured from north-east, that is shown in pink points in model and process of outflow from model by blu points. For # 2 and #5 layers flux capacity-water output constitute 0.005m/ in a day and for # 7 and #10 layers 0.12m/in a day.

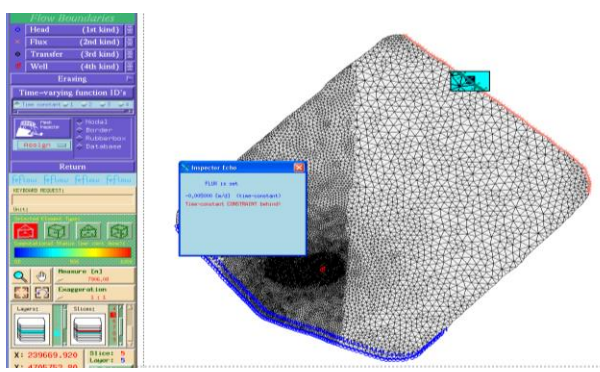

Fig. 8. Flux movement block system for Tsaishi hydrothermal sector

West and east borders of hydrothermal basin show on the model are conditionally non water conductor (Fig. 8).

5. **Implementation of digital modeling**

With the given model we can conduct any type of simulation of thermal area – define balance, field exploitation forcast and etc.

First of all, Tsaishi field's forcast was prepared including current conditions fo exploitation purpose and thermal water balance was calculated from the period of its opening (1983year) up to present, during 30 years period and for next 30 years period operation in the same regime. 60 years in total. As it is shown from drawing, borehole pressure gradually decreases and due to this process discharge is reduced by 4000m^3/24h(from the period of its opening) and by 3000m^3/24has for to date (borehole # 10 shown in red color, # 4 in a blue color). Afterwords, in the case of this kind regime operation, pressure will continue to fall down and we will face so called *Horizon landing.*

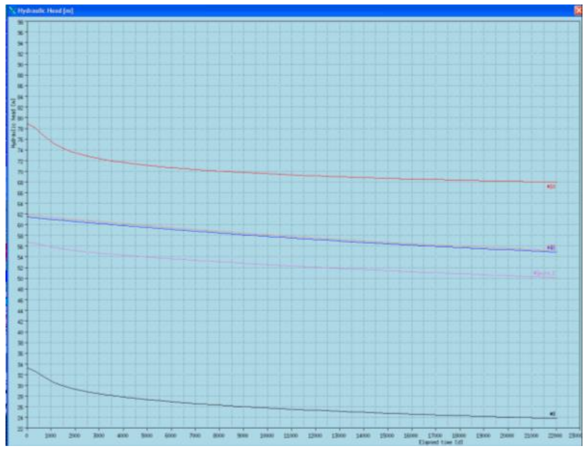

Fig. 9. Pressure changes graphic in the boreholes for 70 years period .

In the process of balance calculation, thermal water's energy lose effect from thermal line borders as well as negative balance fot whole field was detected (Fig. 9-10).

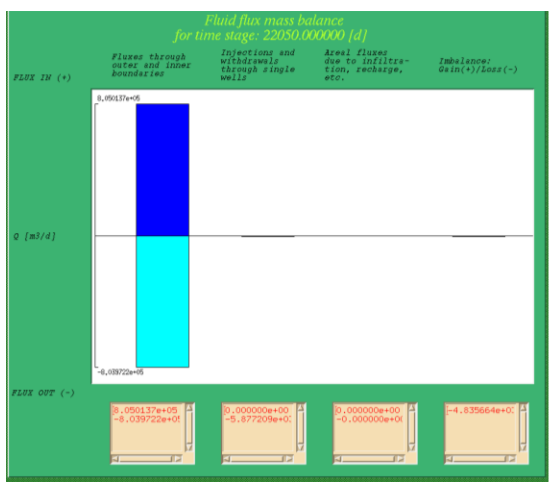

Fig. 10. Balance graphic

On the second stage, possible effectiveness of field's explotation by returning of thermal water was calculated in case if so called geothermal circulation condition will be implemente on Tsaishi area. Namely, the following case was simulated, the hot water taken from the borehole # 10 was pumped into borehole # 4 and at the the same time its effectiveness was calculated for 70 years (Fig. 11).

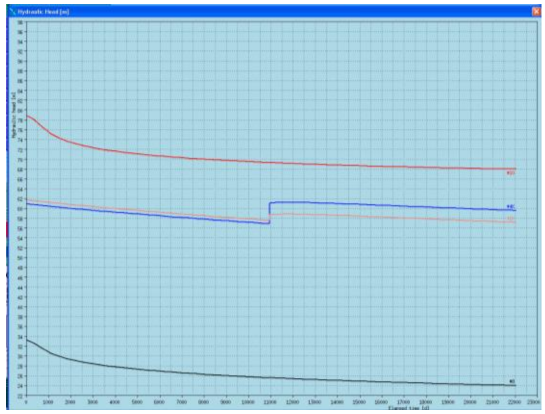

Fig.11. Pressure changes graphic by reinjection for 70 years period

As it is shownt from Fig. 11, pressure restoration process is evident in # 4 and # 1 boreholes after starting reinjection process and reduction of falling tendency.

Accordingly, in minor, but improvement in whole balance for Tsaishi area can be seen where reinjection was conducted (Fig. 12).

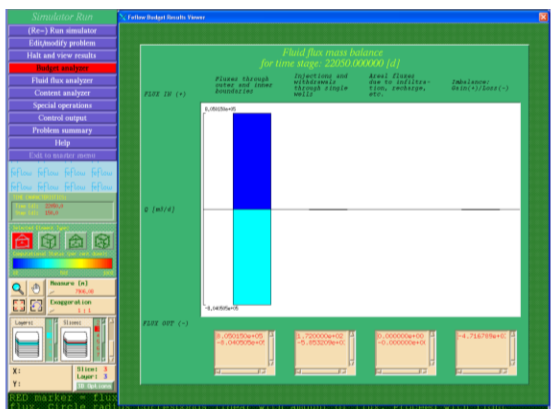

Fig.12. Thermal balance graphics of Tsaishi are for nex 30 yaers

As a result, geothermal circulation system implementation will give an opportunity to avoid outpouring of discharged water that causes thermal pollution of environment and creation of marshes; although by returning discharged thermal water in water exchanger horizon water massive waste will practically be equal to zero. So, pressure fall in water exchanger layer will not occur and this will increase reservoir exploitation period for a long time.

6. Conclusion

The following achieved after project implementation:

Improved Tsaishi public school heating system's efficiency that will ensure normal micro climate in the building;

Hot water supply system operated

Tsaishi geothermal field's section digital model created and possibilities for Geothermal circulation system arrangement determined.

7. Reference

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Создание цифравой модели Цайского геотермального резервуара для организации геотермальной циркулайионной системи

Георгий Меликадзе, Генадий Кобзев, Нино Капанадзе, Мариам Тодадзе

Резюме

Главной целью данного проекта является создание первой циркуляционной, с повторным закачиванием воды, системы на геотермальном поле Цаиши (Грузия) для тепло и горячоводоснабжения Цаишской государственной школы с использованием чистого возобновляемого источника энергии.

Для достижения главной цели проекта было организовано гидрогеологическое тестирование существующих скважин для определения свойств скважин и создания модели водоносного горизонта. Цифравое моделирование отражает главные шаги калибровки процесса симуляции, дает возможность оценить и изучить различные сценарии эксплуатации и развития процессов.

ცაიშის გეოთერმულ საბადოზე გეოთერმული ცირკულაციური სისტემის ორგანიზების მიზნით ციფრილი მოდელის შექმნა

გიორგი მელიქაძე, გენადი კოზზევ, ნინო კაპანაძე, მარიამ თოდაძე

abstraqti

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