ESTIMATION THE RESERVOIR TEMPERATURE BY USING THE SILICA- ENTHALPHY MODEL OF GEOTHERMAL WATER RESULTING FROM FOUR WELLS SITUATED IN THE WEST ROUMANIA

M.Sebesan[1], G.E.Badea[1*] ,R. Sebesan[2], O.Stanasel[1],A. Setel[3]
[1]University of Oradea, Faculty of Sciences, Str.Universitatii nr.1, 410087, Oradea, Romania, msebesan@uoradea.ro, *corresponding author: gbadea@uoradea.ro
[2]University of Oradea, Faculty of Electrical Engineering and Information Technology, Str.Universitatii nr.1, 410087, Oradea, Romania
[3]University of Oradea, Centre of Technological Transfer,Str.Universitatii nr.1, 410087, Oradea

Abstract: **The paper presents the estimation of the geothermal reservoirs temperature using the silica-enthalphy model. The reservoirs temperatures were calculated with chalcedony geothermometers, by Watch simulation program. There were proposed to estimate the deep waters temperatures using the silica- enthalphy model and to compare this temperatures with the temperatures resulting from geothermometers which were calculated by the Watch program. We establish the chemical data of the water in 2010. Based on the chemical composition by these of Watch simulation pogram, they were estimated the minerals which can precipitate during production of the studied wells.**

Keywords: geothermal water, silica- enthalphy model, geothermometer, Watch program

1. INTRODUCTION

The geothermal energy has been used for heating, for industry, and for generation of electricity. In our country the geothermal reservoirs are mainly located in the western part. This paper presents the estimations the deep water temperature for geothermal water resulting from: well 4699 from Cighid, well 4175 Tăşnad, well 4777 Mădăras and well 507 Livada. 4699 geothermal well is situated in the yard of the hospital for children with severe handicap from Cighid, located at about 3,5 km south-west from Ghiorac town and 4 km far from Ciumeghiu village. Starting 1998 geothermal energy from Cighid was use the water for heating the hospital.

Geothermal well 507 from Livada drilled in the year 1979. Currently geothermal water used up to heating of houses, to heating of social objectives, to heating of a greenhouses and to swimming place the summer.

The drilling 4175 from Tăşnad is situated in the county Satu –Mare. The utilization of geothermal energy from Tasnad is done for heating military unit, to heating of a greenhouses and to heating of houses. Well 4777 from Mădăras is situated in the northern part of village, near swimming place. Water extracted is drived in thermal swimming place.

The reservoirs temperatures were estimated using the silica- enthalphy model. Watch program show us the deep waters temperatures, calculated which geothermometer chalcedony, geothermometer quartz and geothermometer Na/K.

2. EXPERIMENTAL DATA

In this paper we utilized Watch program for calculus deep waters temperatures.

The Watch program predict possible scaling what occured during the utilization of geothermal water and with geothermometers indicates the reservoirs temperatures.

Geothermal waters from Cighid and Madaras were analysed by using standard analytical methods.

The results are presented in tables 1.

In this paper we utilized Watch program for calculus deep waters temperatures. The Watch program predict possible scaling what occured during the utilization of geothermal water and with geothermometers indicates the reservoirs temperatures.

The use of geothermometers is based on the supposition that there is an equilibrium between minerals from the rocks of the reservoir and the fluid from the reservoir.

The chemical composition of the surface fluid is controlled as main by the composition of the minerals from the reservoir and the temperature. Arnorsson and Fournier [1] concluded that the solubility of some components of the geothermal fluid is controlled by the temperature.

The temperatures resulting from geothermometers which were calculated by the Watch program are presented in table 2.

Table 1. Characteristics of geothermal water from Cighid, well 4699 and Madaras, well 4777 in mg/l, in 2010.

Chemical Characteristics	Well Cighid 4699	Well Madaras 4777
pH	8,0	7,2
Na^+	1205	1490
K^+	10,2	22,5
Ca^{2+}	19,1	8,4
Mg^{2+}	3,3	5,2
Cl^-	743	607
SO_4^{2-}	28	160
HCO_3^-	2150	2720
SiO_2	48	30,5
Fe^{2+}	-	0,7
CO_2	1550	1900
Mineralization	4295	5200

Table 2. Temperatures resulted by Watch program calculations.

Well	T (quartz) °C	T (chalcedony) °C	T(Na/K) °C
Tasnad	86,5	96,0	39,8
Madaras	77,5	95,6	48,6
Cighid	90,9	104,5	116,0
Livada	150	59,7	289,9

Is noticed as temperature calculated by chalcedony geothermometer [2] is very close to the production temperature of majority geothermal waters than the values given by the other geothermometers.

Another way to estimate the reservoir temperatures is by using the silica-enthalpy mixing model [2]. On the strength of contained of silica from geothermal waters and of surface reservoir temperatures we caused the enthalpy for geothermal fluids.The results are presented in table 3.

It is assumed that the surface geothermal water is the result of mixing of hot geothermal water with cold water. The intersection point with the solubility curve for chalcedony gives the enthalpy of the deep hot water component and its temperature is obtained from steam tables, Model silica-enthalpy for wells: 4699 Cighid, 4175 Tăşnad, 4777 Mădăras and 507 Livada was presented in figures 1, 2, 3, and 4.

Table 3. Concentration SiO_2, temperatures and enthalpy of surface for wells from Cighid, Livada, Tasnad and Madaras.

Well	SiO_2 (mg/l)	Temperature to surface,°C	Enthalpy [kj/kg]
Cighid 4699	43	80	335,2
Livada 507	120	89	372,91
Tasnad 4175	40,1	70 – 74	297,49
Madaras 4777	66,5	50	209,5
Cold water	20	10	42

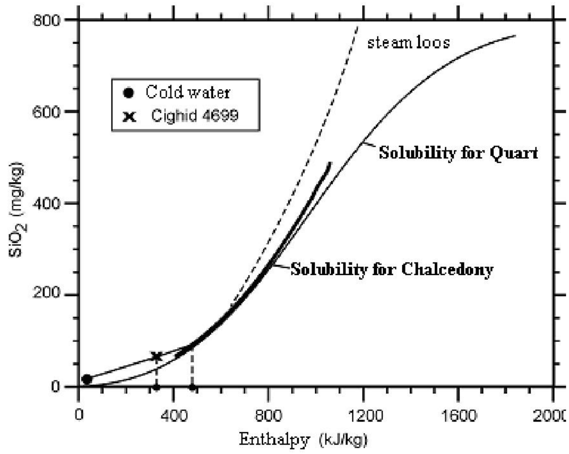

Fig. 1. Diagram of dissolve silica-enthalpy.

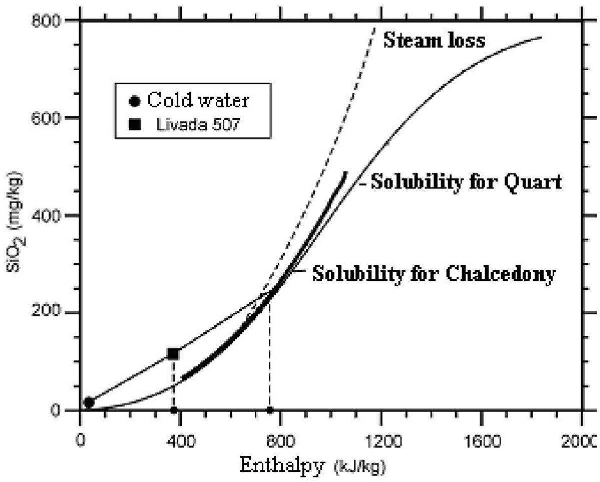

Fig. 2 Diagram of dissolve silica-enthalpy.

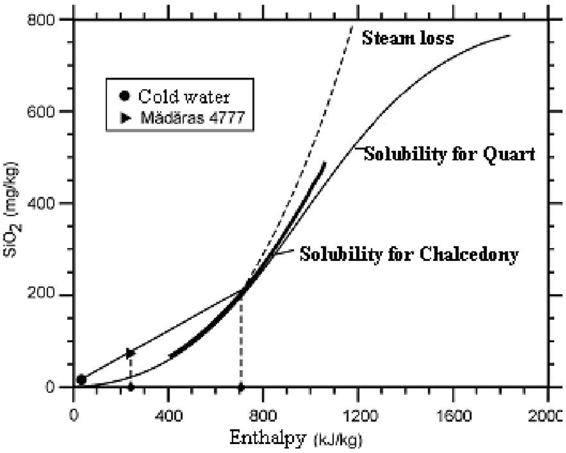

Fig. 3. Diagram of dissolve silica-enthalpy.

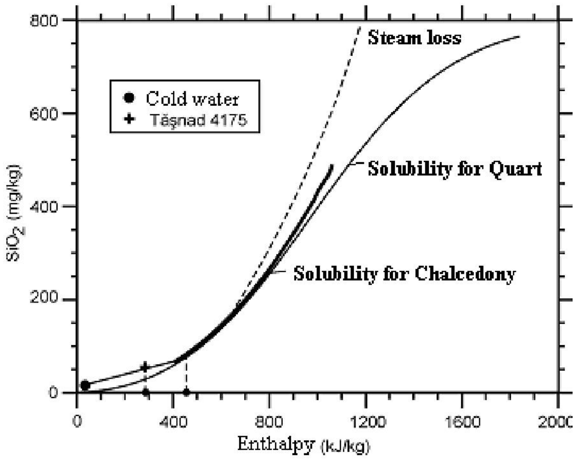

Fig. 4. Diagram of dissolve silica-enthalpy.

3. RESULTS AND DISCUSSIONS

The reservoir temperatures finded out with silica-enthalpy model are presented in table 4.

Table 4.Temperatures resulted by silica-enthalpy model calculations.

Well	SiO_2 (mg/l)	Enthalpy in reservoir, [kj/kg]	Hot water temperature in reservoir, °C
Cighid 4699	43	476,28	113,4
Livada 507	120	780,62	186,1
Tasnad 4175	40,1	451,01	107,4
Madaras 4777	66,5	701,40	167
Cold water	20	42	10

At Livada, well 507 the temperature calculated by mixing model is 186,1°C, and for well 4777 of Mădăras the temperature calculated by mixing model is 167°C, therefore differed the temperature calculated by chalcedony geothermometer. The difference compared to the wellhead temperature is assumed to be due to mixing with cold water in the upper layers or due to contact by the cold rocks.

At Tăşnad, well 4175 and at Cighid, well 4699 this temperature calculated by mixing model is 113,4°C, respectivly 106,1°C. For this geothermal wells, the temperatures calculated by chalcedony geothermometer is 96,0°C for geothermal water of Tăşnad and 104,5°C for geothermal water of Cighid. The temperatures calculated by chalcedony geothermometer is very close to the production temperatures of geothermal waters from Tăşnad, well 4175 and from Cighid, well 4699.

Table 5. The values of saturation indices of minerals may be separated by cooling the geothermal water in the 4699 well at different temperatures in Cighid, in 2010.

Temp. °C	Log. Q/K (Anhyd.)	Log.Q /K (Calcite)	Log.Q /K (Chalc.)	Log.Q/ K (Quartz)
82	-2,791	1,125	0,011	0,34
60	-2,759	1,165	-0,041	0,281
40	-2,891	1,007	0,179	0,524
25	-2,989	0,897	0,361	0,711
Temp. °C	**Log. Q/K (Talc)**	**Log.Q /K (Wollast.)**	**Log.Q /K (Chrysot.)**	**Log.Q/ K (Amorph. Silica.)**
82	4,349	-3,779	1,795	-0,748
60	4,617	-3,64	2,197	-0,783
40	3,531	-4,224	0,536	-0,643
25	2,718	-4,698	-0,786	-0,511

By the use of the program it was calculated the ionic activity Q corresponding to different minerals in the brine and it was compared with the theoretical solubility, K, of the respective minerals. When $Q < K$ the saturation index is negative and the solution is undersaturated with respect to the mineral considered. When $Q > K$ the solution is supersaturated and when $Q = K$ the solution is exactly saturated or in equilibrium with the mineral in respect. Changes in water by cooling within the system during utilization can by modelled and subsequent changes in chemistry evaluated. This is an important tool for the assessment of scaling problems.

The results obtained by the Watch program are presented in figures 5 and 6.

The saturation indexes were calculated for the following minerals: calcite, quartz, talc, chrysotile and wollastonite.

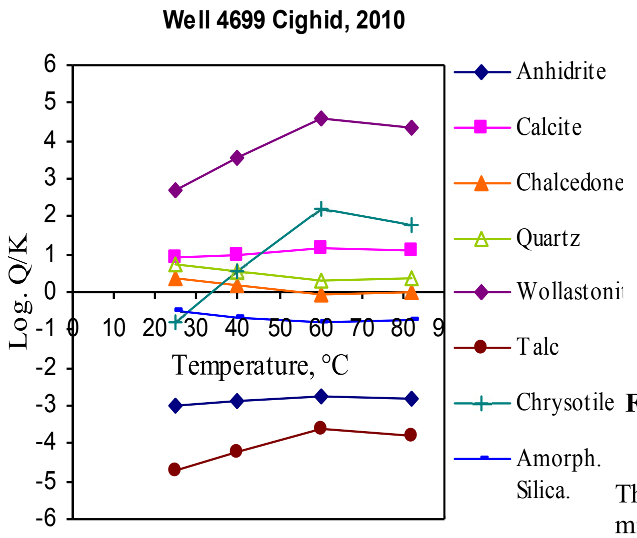

Figure 5. Log.Q/K vs temperature for selected water from well 4699 Cighid, in 2010

TABLE 6. The values of saturation indices of minerals may be separated by cooling the geothermal water in the 4777 well at different temperatures in Madaras, in 2010.

Temp. °C	Log.Q/K (Anhyd.)	Log.Q/K (Calcite)	Log.Q/K (Chalc.)	Log.Q/K (Quartz)
79°C	-4,006	1,012	-0,011	0,313
60°C	-4,205	1,002	0,055	0,577
40°C	-4,538	0,989	0,188	0,771
25°C	-4,841	0,873	0,384	0,903

Temp. °C	Log.Q/K (Talc)	Log.Q/K (Wollast.)	Log.Q/K (Chrysot.)	Log.Q/K (Amorph. Silica.)
79°C	5,341	-2,986	2,812	-0,746
60°C	5,154	-3,125	2,542	-0,632
40°C	4,813	-3,372	2,233	-0,591
25°C	4,232	-3,719	1,824	-0,464

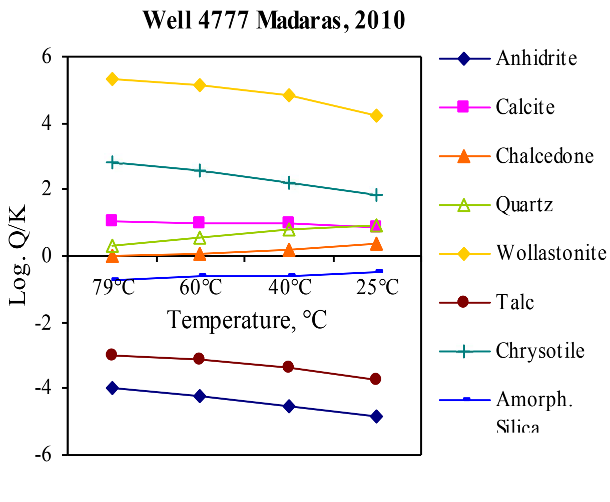

Figure 6. Log.Q/K vs temperature for selected water from well 4699 Cighid, in 2010

The saturation indexes were calculated for the following minerals: wollastonite, chrysotile, calcite and quartz.

4. CONCLUSIONS

The reservoir temperatures indicated by the calculated chalcedony geothermometer is closer to the production temperatures of the water than the values given by the other geothermometers.

The reservoir temperature calculated by silica-enthalpy mixing model is rather higher than the temperature given by the chalcedony geothermometer and the wellhead temperature, which indicates a mixing of hot water from the reservoir with the infiltrated cold water in the upper layers. A simulation program was used to estimate the depositions which can be formed at different temperatures reached during geothermal water utilization. It is better to avoid scales before they occur. In case of mineral depositions inside the pipes a mechanical removal is not convenient. Geothermal waters with a scaling tendency must be treated by chemical method in order to prevent the deposits.

REFERENCES

[1.] Fournier R. O., Geothermics, Vol. 5., 1977.

[2.] Bjarnason J.O., The speciation program Watch, version 2.1. Orkustofnun, Reykjavik, 1994.

[3.] Arnorsson, S., J.Volc.Geotherm.Res., Vol. 2.3, 1985.

[4.] Giggenbach W.F., Geochim. Cosmochim .Acta, Vol. 52, 1988.

[5.] Keenan, J.H., , Steam Tables-Thermodynamic properties of water including vapor, liquid and solid phases, International Edition-metric units, Wiley, New York, 1969.

[6.] Mackenzie, W.S., Guilford, C., Atlas of rock-forming minerals in thin section, Longman U.K., 1982.

[7.] Sebeşan M., Stănăşel, O., Sebeşan, R., Proceedings of the World Geothermal Congress, Atalya-Turkey, 2005.

[8.] Arnorsson S., Stefansson A., Proceedings of the World Geothermal Congress, Atalya-Turkey, 2005.