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SCALING PROBLEMS RECORDED AT GEOTHERMAL WELLS FROM BORS AND SACUIENI, ROMANIA

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ABSTRACT

Data from a few Romanian geothermal fields were selected. Emphasis was placed on the geothermal fields of Bors and Sacuieni due to the chemical changes which have been observed there. Two wells of these geothermal fields have been used for chemical monitoring. For this purpose, samples have been collected and analysed by using standard methods.

Based on the chemical composition of these waters, by using a chemical computer program were assessed scaling problems. The composition of depositions depends on the temperature changes. Severe scaling problems have been encountered both at Bors and Sacuieni. The scale deposits were analysed thermic differential and by X-Ray diffraction. The experimental results were compared to those, which were obtained by using the computer program.

INTRODUCTION

The aim of this study was to predict possible scaling during production in some Romanian geothermal fields. The fields chosen for this study are the Bors and Sacuieni reservoirs. Chemical analysis were made of geothermal water from two wells, Bors-529 and Sacuieni-4058.

The chemical composition of the fluids in Bors and Sacuieni is different. The wellhead temperatures are 84^0C in Sacuieni and around 90^0C in Bors. The Watch program was used to model what happens in geothermal fluids under different conditions, first at reservoir temperature and then at lower temperatures which are reached in the distribution system during production. Scaling test devices were installed and later analysed by using analytical methods.

GENERAL DESCRIPTION OF THE FIELDS

Geothermal exploration started in Romania in 1962. According to the characteristics of the geothermal reservoirs and to the territorial position, six distinct geothermal systems were identified: four are in the western part of the country in the Pannonian Basin; one is in the Olt Valley, in the median part of Southern Carpathians; one is in the Moesian Platform area, around Bucharest. The distribution of geothermal activity in Romania is shown in Figure 1.

Figure 1. Geothermal fields in Romania.

The Bors geothermal reservoir is situated at about 6 km northwest of Oradea. It is a closed aquifer with a surface area of 12 km^2. This is the hottest geothermal reservoir, the wellhead temperature being 90-120^{0}C. Sacuieni is situated at about 60km north of Oradea. The wellhead temperature is in the range of 74-85^{0}C.

ANALYTICAL RESULTS

Waters from two selected wells, one from Sacuieni and one from Bors were sampled for analysis using standard methods in the chemical laboratory at Oradea. The results of the laboratory analyses are summarized in Table1.

Analytical methods used for the constituents determined are the following:

- total carbonate was determined by electrometric titration;
- ammonium – spectrophotometric determination at λ=420 nm;
- boron – spectrophotometric determination, using azomethine; absorption was recorded at λ=420 nm;
- silica – spectrophotometric determination using ammonium heptamolibdate; absorption detemined at 410 nm;
- sodium, potassium – flamephotometric determination, λ=589nm, respective λ=767nm;
- magnesium, calcium – titration with EDTA;
- chloride, sulphide – ion chromatography;
- ferrum – spectrophotometric determination at λ=510nm, using o-phenantroline;
- total dissolved solids – gravimetric analysis.

The wellhead temperatures measured during collection of water samples was about 90^{0}C at Bors and 84^{0}C at Sacuieni. The pH is neutral at Bors and slightly basic at Sacuieni. The mineralisation of geothermal waters from Bors and Sacuieni is around 11 g/l.

Table 1. Chemical composition of geothermal water from well-529 from Bors and from well-4058 from Sacuieni, in 1999, in mg/l

Component	Well-529	Well-4058
CO_2	1068	2122
NH_3	5.2	6.4
B	49	78.9
SiO_2	127	62.9
Na	4230	1610
K	385	21.3
Mg	13.2	4.1
Ca	122	13.2
Cl	6320	911
SO_4	115	5.9
Fe	9.6	0.25
TDS	11210	11647

As seen from the table there are great differences between the major components concentration in geothermal water in well-529 Bors in comparison to well-4058 Sacuieni. Sodium and chloride concentration are very high at Bors. The calcium and sulphate concentration are also rather high.

SCALING PREDICTION

The potential scaling problems of a geothermal utilization depend on the type of water. Therefore, a reliable analysis of the water and a simulation of the changes occuring during the utilization are needed to predict possible scaling.

The program Watch is commonly used for interpreting the chemical composition of geothermal fluids. In this paper the program was used to compute the concentrations of resulting species, activity products and solubility products when the equilibrated fluid is allowed to cool conductively from the reference temperature to some lower temperature. The scaling potential is estimated by calculating logQ/K, where Q means the ionic activity corresponding to different minerals in the brine and K the theoretical solubility of the respective minerals.

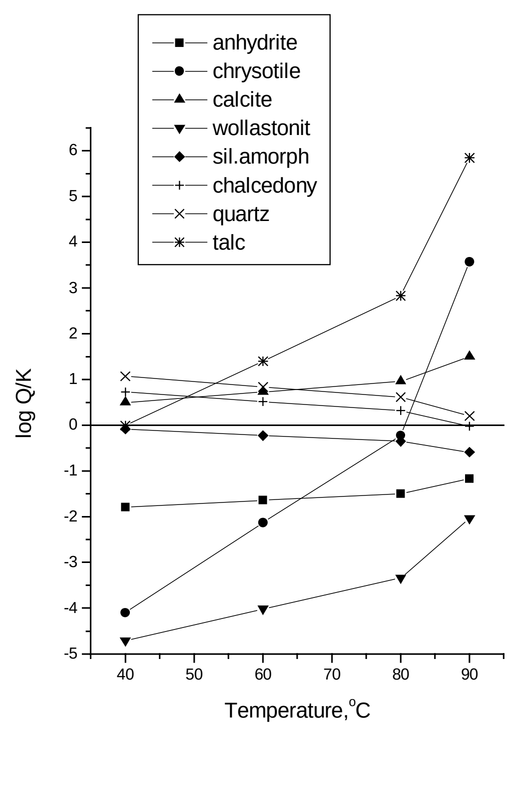

Figure 2. LogQ/K vs. temperature for selected geothermal water from well-529 Bors in 1999

The data presented in Table 1 have the ionic balance within admissible limits, but unfortunately some chemical components coud not be analysed, so the ionic balance does not reflect exactly the reality.

For Bors well 529 and Sacuieni well 4058, the Watch program calculated the log solubilities for many minerals. Figure 2 shows that logQ/K for calcite exceeds 1 at the wellhead temperature, that is considered to be very dangerous. Anhydrite, amorphous silica, and wollastonite are undersaturated and there is an equilibrium with chalcedony at 90^0C. Quartz is slightly supersaturated at the wellhead temperature. Chalcedony and quartz become supersaturated at lower temperatures. A potential chrysotile scaling could be expected at 90^0C. Talc is supersaturated, but this does not create problems.

Figure 3 shows that anhydrite, amorphous silica and wollastonite are undersaturated. The equilibrium temperature for chalcedony is very close to the measured temperature. The water is close to saturation with quartz and it is saturated with chrysotile and talc at the wellhead temperature. Calcite is supersaturated at 84^0C. If the temperature of geothermal water were to decrease calcite would still remain supersaturated and chrysotile become undersaturated; chalcedony and quartz lie close to the saturation line.

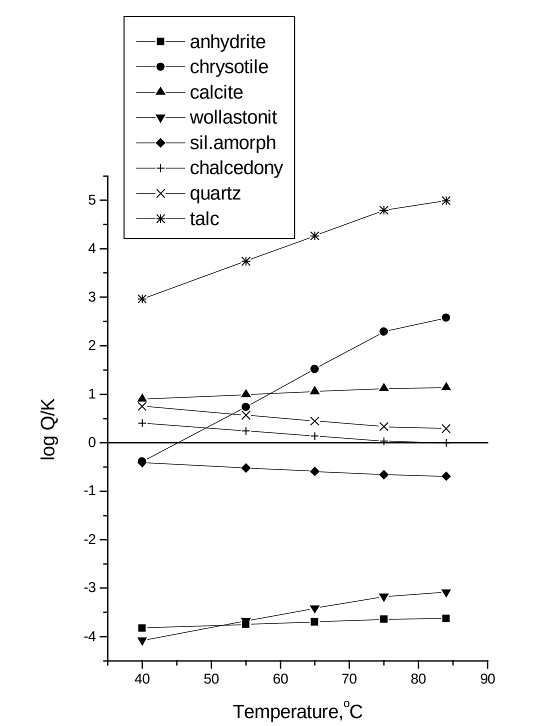

Figure 3. LogQ/K vs. temperature for selected geothermal water from well-4058 Sacuieni in 1999

DEPOSITIONS ANALYSIS

Major problems have arisen in a few heating services from Bors and Sacuieni due to scaling processes. Test plates have been installed within the pipelines both at well-529 from Bors and at well-4058 from Sacuieni, for monitoring. The test plates showed significant changes when inspected after about a half of year. The test plates were covered by depositions.

There were made quantitative analysis to determine the concentration of the elements which are presented in the solid depositions from Bors. The solid samples were first disintegrated. Calcium, magnesium, aluminium and ferrum were complexonometric determinated. The chemical results are shown in Table 2

Table 2. Chemical composition of solid depositions from Bors, well-529, in %.

MgO %	Al_2O_3 %	Fe_2O_3 %	CaO %	Calcined loss
1.1	0.3	0.4	54.4	42.7

Data from Table 2 demonstrated that calcium is the main element of solid depositions from well-529 Bors. That could mean a calcite scaling as main. After this preliminary analysis the test plates were analysed by X-ray diffraction. The XRD studies were made using K∀Cu radiations, giving information about the existence of crystals in the solid sample. The diagram (figure 4) obtained for the solid depositions from well-529 Bors shows there are aragonite crystals in the sample. The solid sample was then thermic-differential analysed, by using Derivatograph Q-1500D equipment. The diagram (figure 6) shows that at 650^0C it starts a slow and continue decomposition process, which has a maximum at 930^0C. The mass loss is about 43.2% in the range of temperatures 650-1000^0C, that means that all depositions sample consists of $CaCO_3$ as main, the loss being CO_2.

The test plates from well-4058 from Sacuieni were also analysed by X-ray diffraction. The XRD diagram (figure 5) shows that there are calcite and magnesian crystals in the deposition sample. The solid sample was also thermic-differential analysed. The diagram (figure 7) shows an endothermic effect which starts at about 693^0C and it has a maximum at 950^0C. The mass loss is 44%, that means that the sample contains carbonates as main, the loss being CO_2.

CONCLUSIONS

Samples were taken from wells from Bors and Sacuieni and analyses were made. The chemical composition of these geothermal waters were interpreted by using the Watch program, which gives information about the mineral equilibrium and a basis to assess possible scaling problems.

Severe scaling problems were encountered both at Bors and Sacuieni. For monitoring of scaling, test plates were installed in well-529 Bors and well-4058 Sacuieni and observed after about a half of year. The depositions which appeared at geothermal water utilization at Bors and Sacuieni were analysed thermic-differential and by X-ray diffraction. The sample from Bors was also chemical analysed after disintegration. Aragonite, respective calcite, magnesian were the crystals content of the solid depositions.

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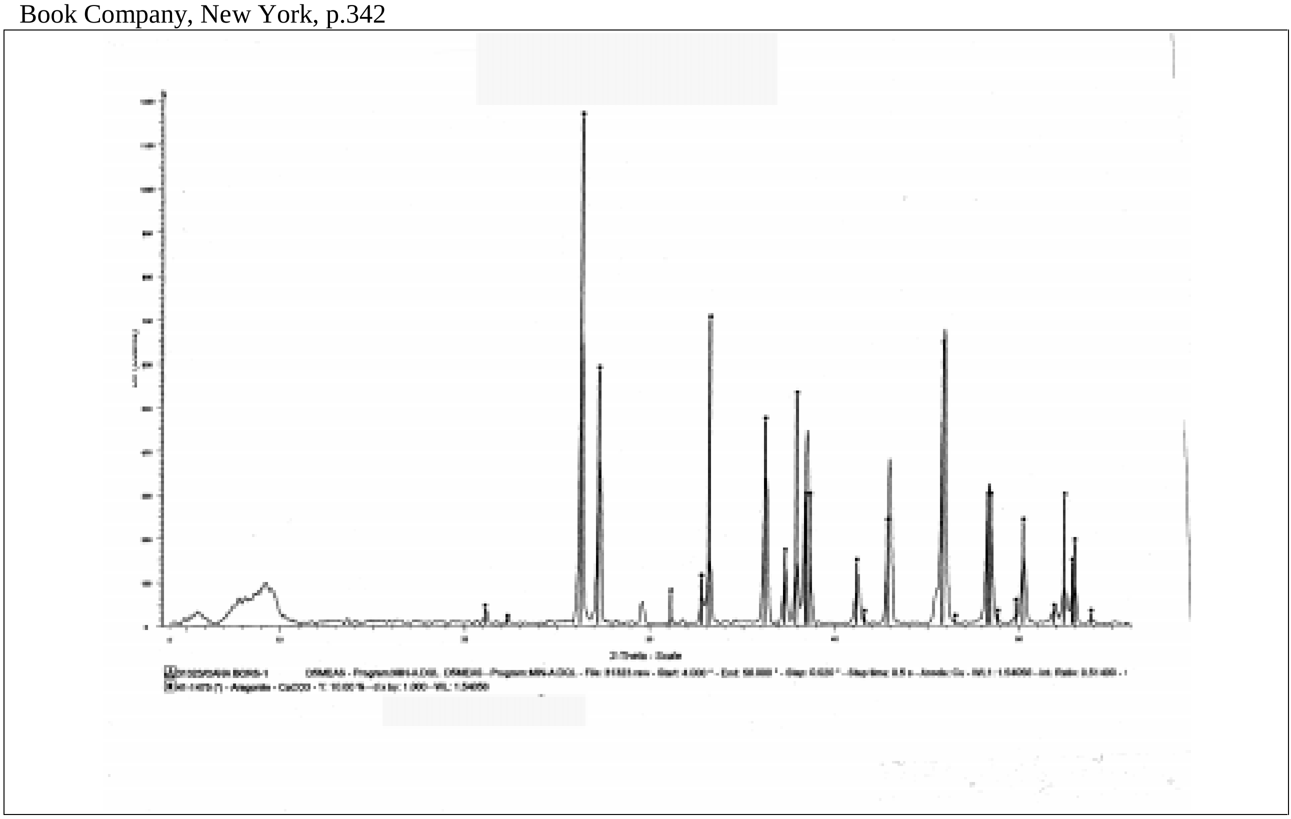

Figure 4. The XRD diagram for depositions from well-529 Bors

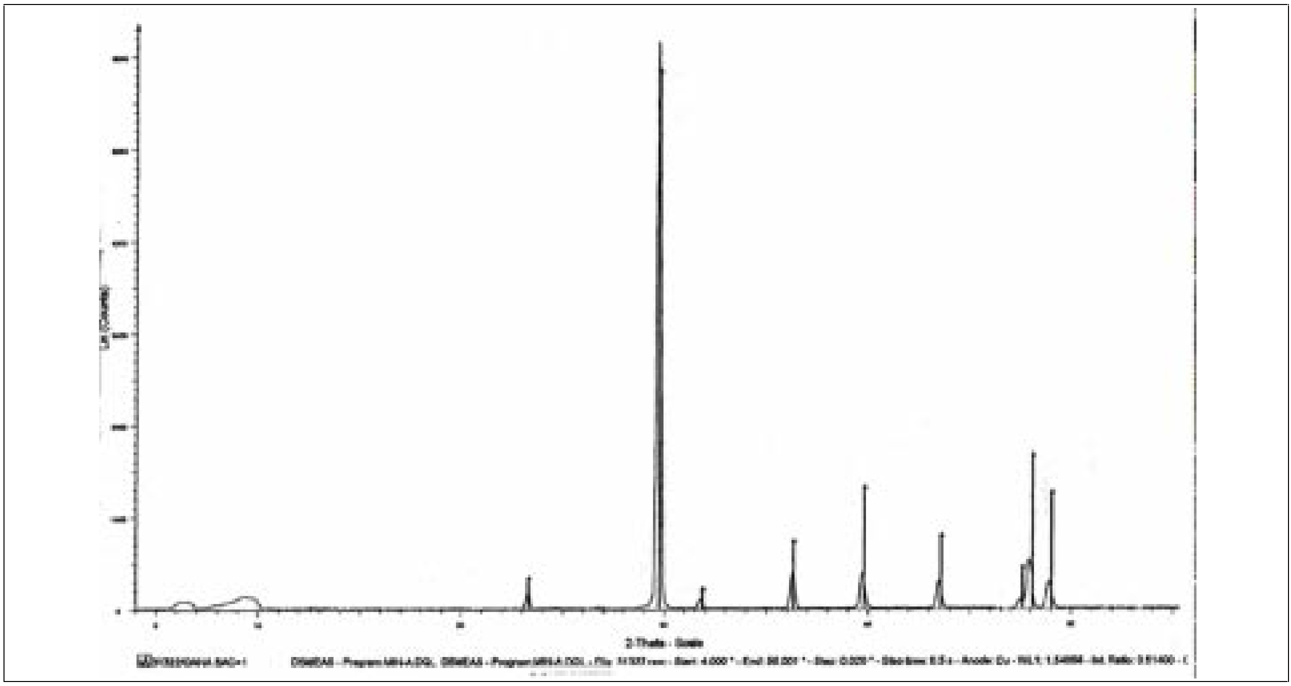

Figure 5. The XRD diagram for depositions from well-4058 Sacuieni

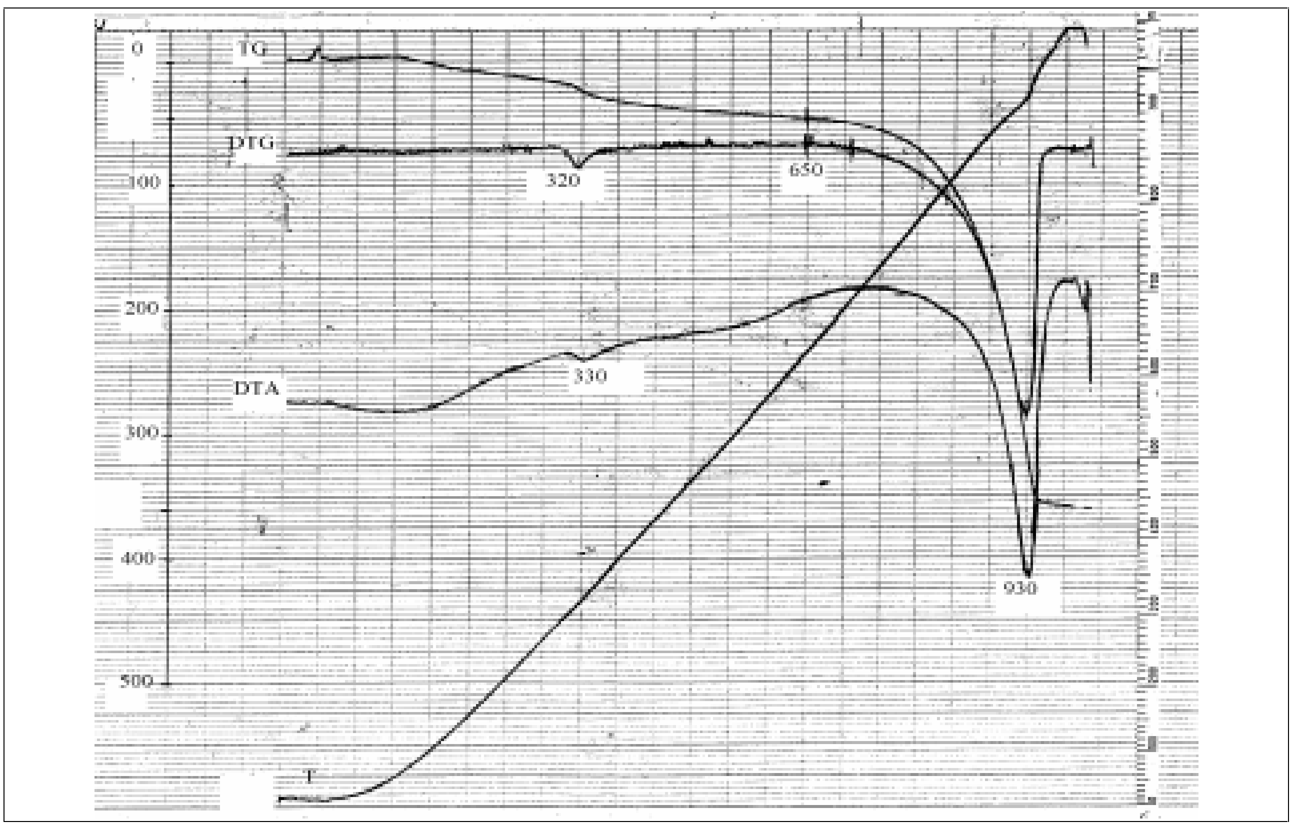

Figure 6. The thermic-differential diagram for depositions from well-529 Bors

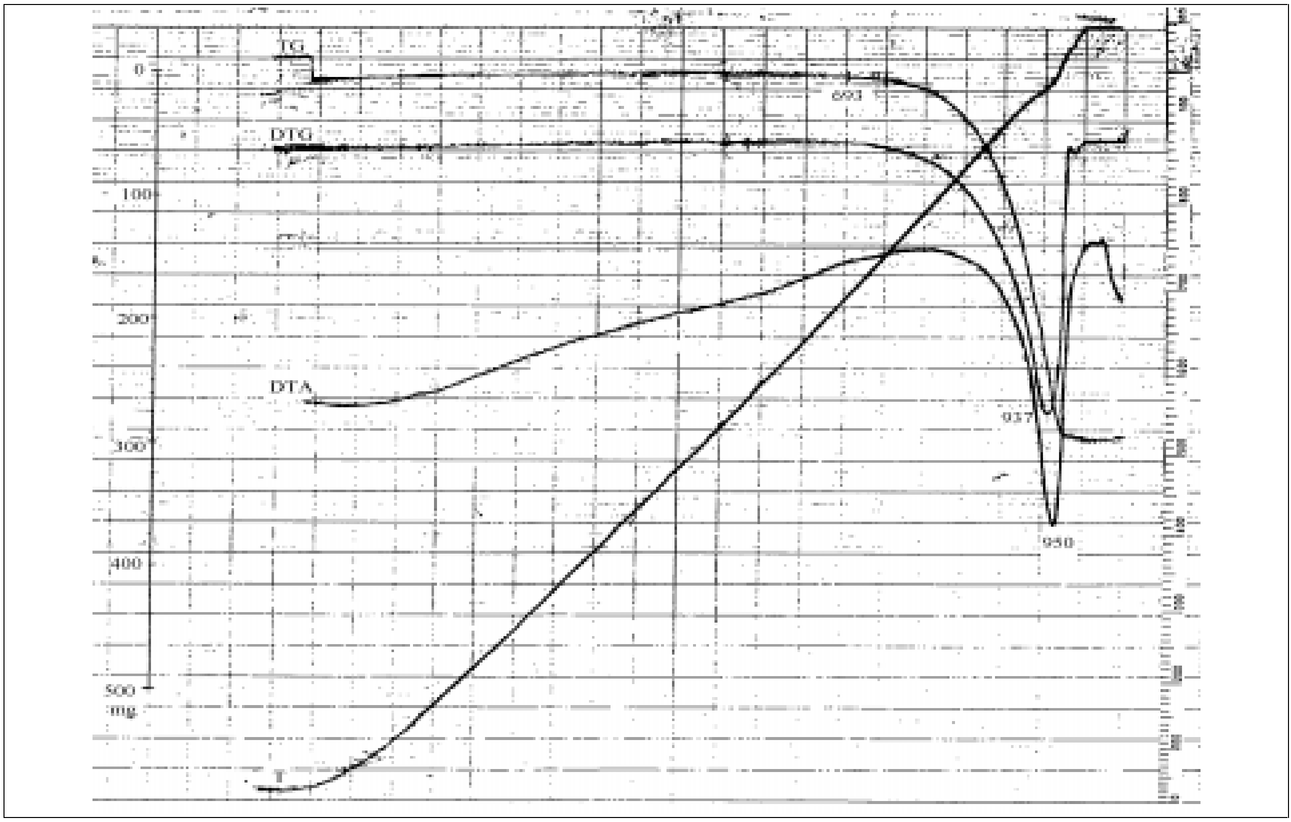

Figure 7. The thermic-differential diagram for depositions from well-4058 Sacuieni