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SILICA IN CERRO PRIETO GEOTHERMAL FIELD

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ABSTRACT

Water-steam mixtures from geothermal reservoirs carry gaseous and solids chemical species (carbon dioxide, hydrogen sulfide, sodium and potassium carbonates, sodium and potassium chlorides, silica, etc.) Their distribution and quantity are dependent from reservoir temperatures and its geochemical structure.

In liquid-dominant geothermal resources operating in steam/brine separation systems, the physical-chemical equilibrium is broken producing a critical situation about silica behavior. Silica solubility falls rapidly forming colloidal solutions which are difficult to separate, or else silica deposition is presented with a range of problems in systems operation, brine energy uses, or reinjection processes.

The objective of this paper is the silica problem analysis in Cerro Prieto area at Geothermal field in Mexicali, Baja California, Mexico.

INTRODUCTION

Exploitation systems for geothermal plants classified as liquid dominant, present two problems which need to be solved priority. These are (2):

a) The high solids concentration brine conduction. The solids are deposited during the cooling step required in the energy extraction processes. The pipes are plugged up and scaling appears on the equipment surface

b) The reinjection processes are seriously limited by the high content of solids of the separated water.

Geothermal fields such as Cerro Prieto, Wairakei and Niland, have deposits mainly constituited by floculated colloidal amorphous silica (1,3).

It has been observed, in Cerro Prieto Geothermal field, that the initial incrustation is in a vitreous form and the amorphous silica is then deposited on it. As a result, the occurrence of this process will be more frecuently observed in low pressure equipment. And this problem will be acentuated in pipes that operate al low flows. Therefore, the detachment of incrustations and solids transportation to other parts of the systems, are caused by the vibrations and the temperature changes.

The precipitation process has been described according to the following steps (3):

a) Homogeneous nucleation. This is the forming of amorphous silica by polymers that have been raised to a specific size (higher than critical nucleum size). Then, the particles wich have reached this size grow spontaneously and continously.

b) Growing of the amorphous silica particles with a size higher than the nucleum critical size. These particles are large enough to improve the silicic acid deposition on the surface.

c) Coagulation or floculation of coloidal particles to give a gel.

d) Cementation of the particles in the gel by chemical bonding and further deposition of silica between the particles.

When the silica concentration is too high (a supersaturation of 2.5 or higher), the homogeneous nucleation velocity is increased and a massive deposition or scaling ocurrs. This is the case of Cerro Prieto brine when it is separated of the steam and further it is flashed at atmospheric pressure.

When the brine exists in the supersaturation region, solids will be dependent of: supersaturation grade, salinity, temperature, flow type, existence of nucleating particles and pH. The latter is a very important controler of this deposition velocity (4).

There are environmental restrictions to dispose this geothermal brine. Besides, the reinjection is required to improve the life of the geothermal field. Both of these problems show that the control of the solids deposition will become very important when the geothermal exploitation schemes are developed.

This problem becomes more important in the large geothermal projects where typical systems are considered. In these systems 10 Kg of steam are required to generate 1 Kw and 20-40 kg of brine are disposed. Treatment of this brine to attenuate the effects on the surface equipment and on the reinjection systems involves extra costs and operation problems to the generation process.

The best solution would be to avoid supersaturation by selection of the operation conditions. Therefore, the supersaturation must remain close to 1. This imposes design limitations wich have not been accepted to generate economically electrical energy (4,5).

Another way to solve the silica problem is to control the pH. This must remain high by controlling the separation conditions and flash separation or some acids could be added to depress it artificially (2).

Both solutions attempt to avoid the deposition. Also, other methods have been practiced (4) to obtain a controled precipitation, this would allow to dispose the geothermal solids before their conduction or final use, for example: aging of the brine to change the dissolved silica to coloidal (7), inhibition of adhesion to solids surfaces (5) and remotion by coagulation and setting.

When no one of the methods described before are applied, then will be a cleaning problem, which is characterized by (6):

Cleaning is more frecuently needed in some geothermal plants than the cleaning required in a conventional steam power plant.

The cleaning operation will be related to scale properties. The chemical composition of geothermal fluids changes from geothermal field to another, in addition, the chemical composition of the fluid can change over time. Also, the thermodynamic conditions will vary during scale formation.

The silica scales are not very hard, and the deposition rate of them is the controling cleaning factor.

Most elastoineric materials used in analogous cleaning situations are not suitable for geothermal conditions. Maintenance operations on line are complicated with scale removal problems. These waste materials should not be allowed to travel forward other plant sizes.

SCOPE OE WORK

Several efforts have been realized in order to improve solutions to previously described problems. Some of them concern to the brine physical-chemistry, other refer to control scaling methods evaluation about specific applications.

The present work, that is carry-out right now, pretends to analyse the silica problem at Cerro Prieto. The study scope is: silica resources classification, silica inventory, and silica uses.

the first part in the work is finishing in the geothermal area of Cerro Prieto I. Information about well behavior has been revised the last five years.

For the purpose of study ubication, Cerro Prieto I area was divided in four rectangular sections (Figure I). Highest average resevoir temperature (558 °F) was found in the down section to the East, and it corresponded to the average deeper wells (6530 ft), and higher silica brine average concentrations (630 ppm).

19 well are integrated through pipelines to the double steam flashing plant. Waste brine from this plant is delivered to the evaporation pond.

Brine from the other wells is flashed to atmospheric pressure, then it is discharged through channels forward the main colector. Waste water in the main colector is conducted to the station pumping sump, and it is pumping into the evaporation pond.

According to the well information revised, Silica average production was estimated. As a result, nearly

113 571 tons of silica (as SiO_2) have been depositated on the geothermal field land in the last five years (Table I).

TABLE I
Well silica productions

1983	24 885 tons
1984	22 806 tons
1985	23 121 tons
1986	21 432 tons
1987	21 357 tons

Silica production, as is logical, depends of the silica geothermal fluid concentration and its extraction mass rate. According to the results, 19 wells have a clear silica production decreasing tendency in the course of time.

Moreover, silica fluid concentration is subordinated to well localization and reservoir temperature. Six wells showed a silica concentration disminution, and only two wells had an increasing tendency.

Geothermal fluid vapor/liquid mass ratio (V/L) seems to be only function of bottom well pressure and separation pressure. The last one vary in a narrower range. Six wells were having decreasing V/L values, and two shown a increasing tendence.

V/L higher values were detected in 13 wells. Some of them are considered as problematical wells. Generally, they have higher head pressure and higher silica concentration.

Geothermal fluid mass rate disminution wasobserved in 19 wells. It was noticed also that when the V/L values increase, the geothermal fluid mass rate decrease. Well representative behavior is shown in Figures II to VI.

Field samples of brine and solid deposits were taken and analysed. Solid deposits near from the well channels were having silica concentration from 53% to 90% (74% avg.) A silica concentration of 550 ppm was detected in the pump station sump, and 1065 ppm (avg.) of silica were reported in well channels.

Next, the study will be conducted to silica products development. Four kind of products are interesting us: Silicates, ceramics, concrete agregates and silica gels. The goal is to obtain valuable subproducts in order to compensate the brine treatment costs.

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WELL LOCALIZATION

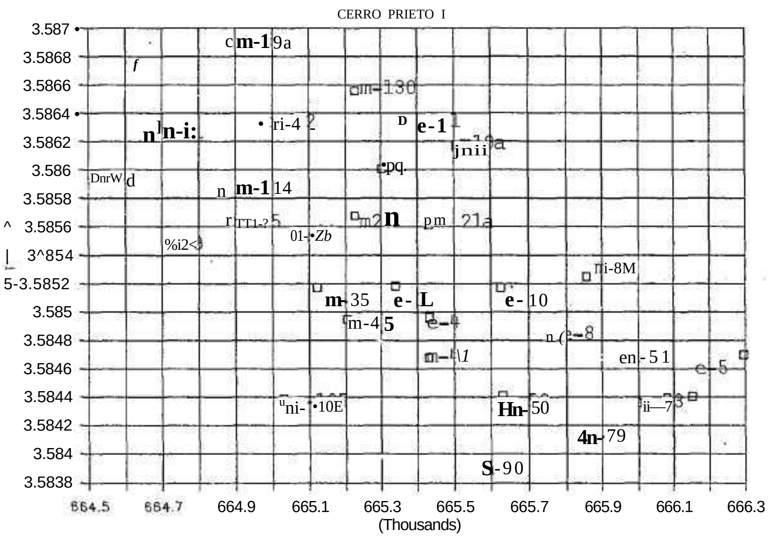
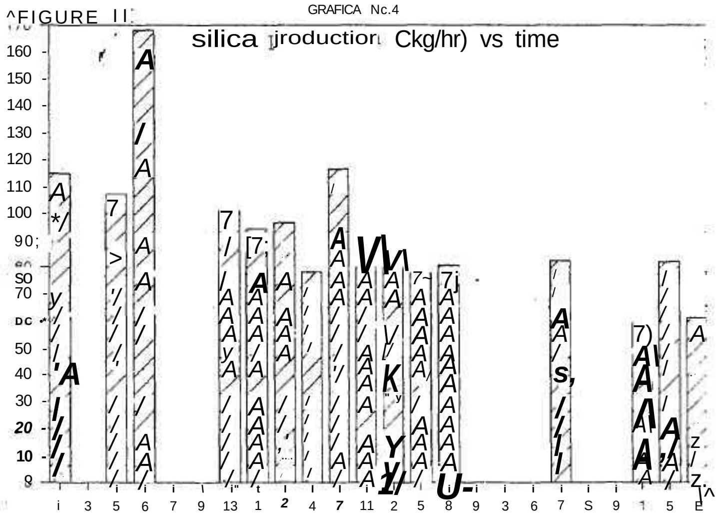


FIGURE I

CERRO PRIETO I

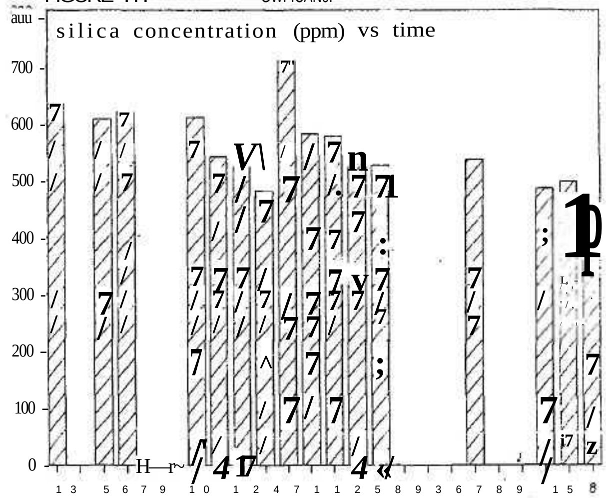
GRAFICA Nc.4

FIGURE II



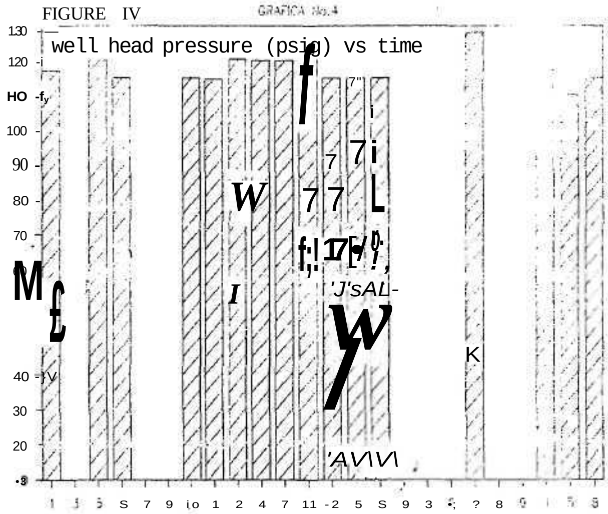
CERRO PRE-

FIGURE III GWFICA No.^



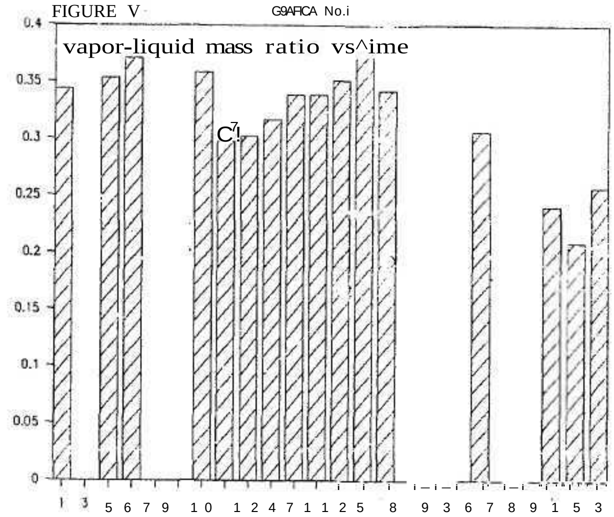
CERRO PRIETO

FIGURE IV GRAFICA No.4



CERRO PR!£'".? !

FIGURE V GRAFICA No.i



CERRO PRIETO

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