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**MECHANISMS AND KINETICS OF CARBON STEEL CORROSION/SCALING AND INHIBITION  
IN ACTUAL OR RECONSTITUTED AND TREATED GEOTHERMAL WATERS**

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**Key Words**

Actual geothermal water, standardized reconstituted geothermal water, carbon steel, corrosion, scaling, petrosourced inhibitor, biosourced inhibitor, hydrogen sulfide, iron sulfide, hydrogeochemical modelling, electrochemical techniques

**ABSTRACT**

Most of the geothermal installations in France are exploiting low-enthalpy geothermal waters of the Dogger aquifer in the Paris Basin. The geothermal operations are made up of two wells (production-injection, both are about 1,800 m deep), and of surface installations. The operating principle is simple: the waters flow assisted through the carbon steel XC38 (CSXC38) casings to the surface and, after flowing through heat-exchangers, are re-injected into the same aquifer, a few hundred meters farther away. Initially, field experience has shown that, in both production and injection well casings, there is corrosion, scaling and, in some cases, partial clogging.

The geothermal waters, exploited by 50 doublets, are highly mineralized and contain dissolved gases, including H<sub>2</sub>S and CO<sub>2</sub>. The main water characteristics are: Anaerobic conditions in which temperatures range from 47-85 °C, pHs from 6.1-6.4, total dissolved solids (TDS) from 6-35 g/L (ionic strength, 0.1-0.6 M) much of which is Cl<sup>-</sup>, [H<sub>2</sub>S/HS<sup>-</sup>] from 5-100 mg/L, [SO<sub>4</sub><sup>2-</sup>] from 300-1200 mg/L, [CO<sub>2</sub>/HCO<sub>3</sub><sup>-</sup>] from 250-600 mg/L. The concentrations of TDS, [H<sub>2</sub>S/HS<sup>-</sup>] and [CO<sub>2</sub>/HCO<sub>3</sub><sup>-</sup>] vary from place to place. H<sub>2</sub>S/HS<sup>-</sup> fluctuates versus time and exploitation flowrate. These characteristics classify them among the foremost corrosive natural waters for carbon steel.

Since 1989, the doublets are treated with various petrosourced organic corrosion inhibitors to prevent corrosion-scaling. Currently, there is no more untreated fluids to use them for testing the effectiveness of new inhibitors, whereas there is a great need to improve the geothermal exploitations.

Thanks to physicochemical analyses (from 15 wells from the Val de Marne, south-est of Paris) and modeling by PhreeqC<sup>®</sup>, a **standardized reconstituted geothermal water** (SRGW) has been realized and approved (tested in stability and composition as a function of time) to be used commonly as corrosive medium for the inhibitors selection. The mechanisms and corrosion kinetics of CSXC38, when immersed at this RGW without inhibitor, acquired electrochemically. The electrochemical behavior of CSXC38, when immersed in RGW treated by a defined concentration of an inhibitor enables the comparison without inhibitor, and then the inhibition efficacy. Several concentrations of the same inhibitor are performed. During the last 5 years, BRGM tested over 30 individual molecules and qualified quite 15 new petrosourced and 5 new biosourced corrosion inhibitors, some of them are now the most commonly used.