ANALYSIS ON SCALING PROBLEM IN INJECTION FACILITIES: A CASE FROM MUARA LABUH GEOTHERMAL FIELD, INDONESIA

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ABSTRACT

Scaling is a common problem in geothermal power facilities. The scaling occurs due to changes in fluid temperature or composition. Mineral scaling is usually found in geothermal power production facilities such as production and injection pipeline. The effects of scaling could reduce steam production to plant, and decreasing injection capacity of injection well.

In the Muara Laboh Geothermal project during the period of long term production test conducted in between 2014 and 2015. Scale materials were identified in the injection pipe line, inside the injection wellbore and water pond. The XRD, Petrography and Scanning Electron Microscope (SEM) analysis on scale materials suggested that the scales consist of mainly amorphous silica.

This amorphous silica scale occurs due to decreasing in injection fluid temperature in the water pond. During the long term flow testing, the high temperature and high silica geothermal fluid was flowed through the Atmospheric Flash Tank (AFT). The produced brine was flowed to the water pond (atmosphere temperature), before it was injected to the injection well. A significant drop in brine temperature has caused the brine to become over saturated with amorphous silica, hence scaling is more likely. Scales are expected to be settling in the bottom of the pond. When the fluid was flowed to the injection well (by gravity), position of strainer in the bottom of the water pond tapped the already oversaturated brine, and amorphous silica was finally scaled-up inside the injection pipe line and the injection wellbore.

This amorphous silica scaling will likely reoccur during the production tests of the development wells as the open injection system (flowed to water pond before it is injected) will be implemented during testing. One action recommended to minimize scaling during production testing, is by using floating strainer. The uppermost section of brine in the water pond is expected to be slightly less concentrated with silica.

1. INTRODUCTION

1.1 Muara Laboh Geothermal Project

The Muara Laboh Geothermal Field is located in West Sumatera; Indonesia (**Figure 1**). Like the other geothermal fields in Sumatra, the filed is located within the Barisan Mountains, which run the length of the island of Sumatra. The mountain range is a young volcanic arc, cut along its length by a major fault system, the Great Sumatra Fault (GSF). The prospect has several surface thermal manifestations such as fumaroles and chloride springs that define the presence of potential geothermal system in the area. The later geologic, geochemical, and geophysical surveys delineated the potential extension of the geothermal system.

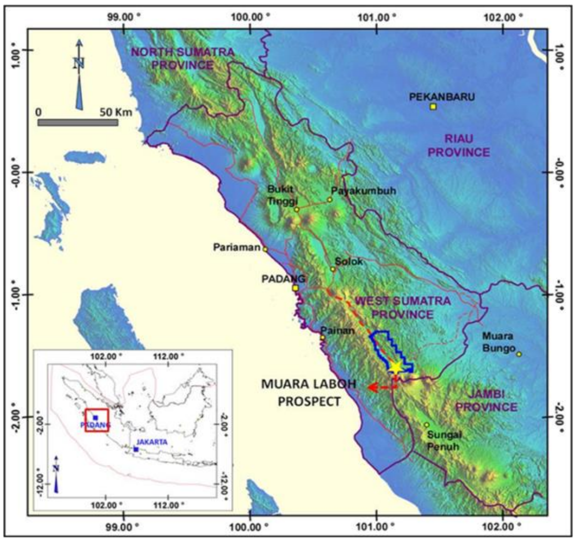

Figure 1. Muara Laboh prospect location

In 2012-2013 PT Supreme Energy Muara Laboh (SEML) drilled six full diameter exploration wells in order to confirm the existence of geothermal system and to assess the field production capacity. During the course of exploration drilling program comprehensive well testing were executed, including pressure and temperature spinner (PT/PTS) survey, completion test, heating-up test, production test and interference test.

During the implementation of the long term production testing, the produced brine was injected into the injection well.

1.2 Scaling in Geothermal

Mineral deposition can occur at any point in geothermal facilities such as wellboree, water pond and at pipeline. Scaling in wellbore could occur due to the saturation mineral on fluid at certain temperature, pressure and chemical conditions. In surface facilities, scaling occurs when fluid flows to the surface, it becomes over saturated with certain minerals (mainly amorphous silica), following the change in physical (PT) and chemical conditions at the surface.

2. SCALES OBSERVED DURING EXPLORATION WELL TESTING

2.1 Background

Scaling was observed during production testing activities after exploration drilling completed in 2014 and 2015. The first was associated with the ML-H1 production test in 2014. The produced brine then was transferred to the water pond at ML-H pad, and then to water pond at ML-A pad before it was injected to the injection well (Ml-E1). At the end of the production test, the injection capacity observed to be decreasing.

The second indication of scaling was observed during the annual pressure and temperature (PT) survey conducted in 2015. Prior to conducting the survey, fresh water was injected to check the injection pipe line capacity. The injection rate could not reach the designed maximum capacity of the pipeline. In addition, injectivity of the injection well was observed to be decreasing.

2.2 Injection Pipe Line Scaling

Detailed injection pipe line inspection was performed to investigate the decrease in pipe line capacity and injection well injectivity, which the results showed scales deposited inside the injection pipe line from water pond at pad ML-H and ML-A (**Figure 2**).

This scaling is suspected to happen during ML-H1 long-term test where the produced brine was injected to an injection well. The thickness of scaling inside pipe line injection is about 5 mm. All scaling materials were removed mechanically, and scale samples were sent for detail analysis.

Figure 2. Major Scale inside the injection pipeline

2.3 Scaling Inside Injection Wellbore

During the annual pressure and temperature (PT) campaign conducted on June 2015, the PT tool was not able to pass 793 m MD of the ML-E1 injection well. Downhole video run later identified obstruction at that depth, which appeared to be scale deposits (**Figure 3**). About a year later, the scale was able to be removed with broaching method, and some scale samples taken and sent to laboratory for detail analysis.

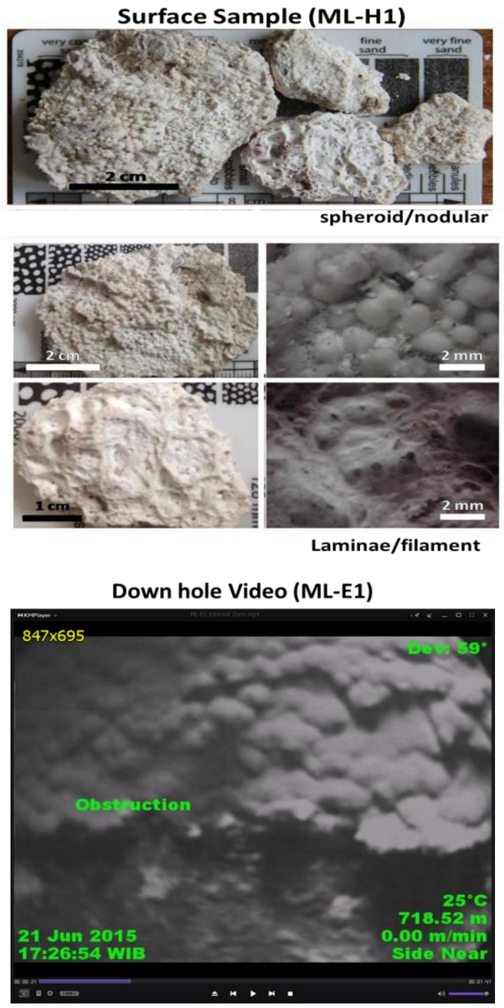

Figure 3. Scale material inside well bore injection well.

3. SCALES ANALYSES

3.1. Physical Appearance

Two sets of scale samples, including the scale sample from injection pipe line (sample A), and sample taken from the injection well ML-E1 wellbore (sample B) were analysed. The analyses method performed included petrography, x-ray diffraction (XRD) and scanning electron microscope (SEM).

Figure 4 shows the picture of the scale samples mentioned. Megascopically sample-A has a layering texture consisting of white colour mineral intercalated with soft brown materials as a impurities. Meanwhile sample-B shows a granular texture like sand.

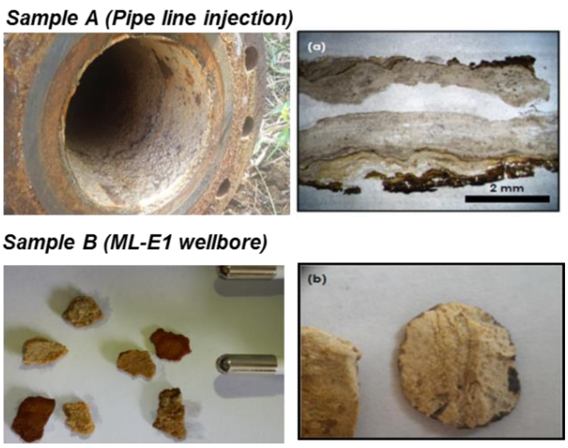

Figure 4. Scaling sample in megascopic condition

3.2 Petrographic Analysis

Petrographic analyses shows the lack of crystal form in sample-A. The sample has bright filaments (colourless) and dark with geyserite texture, especially columnar geyserite corresponding flow patterns, palisade and streamer textures. The other texture is crustiform-colloform banded texture, the characteristic of amorphous silica (**Figure 5**).

Unfortunately, sample B couldn’t be analysed with petrographic method due to the small size and very soft.

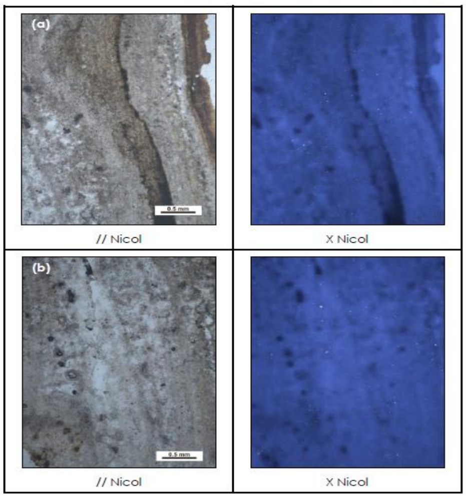

Figure 5. Petrographic picture from Sample A thin section

3.3 X-Ray Diffraction (XRD) Analyses

Two samples (Sample A and Sample B) of a whitish scale deposit were submitted for XRD analysis. These samples were analysed as powders. XRD analysis show both samples are very similar, there are no crystalline mineral forms and in 20º2Q position or 4 Å. This material have a *hump* structure is an characteristic of amorphous silica. The XRD test results charts for these samples are presented in **Figure 6**. The upper graph is from sample A and below graph is from sample B. Both result indicate that scales consist of Amorphous Silica

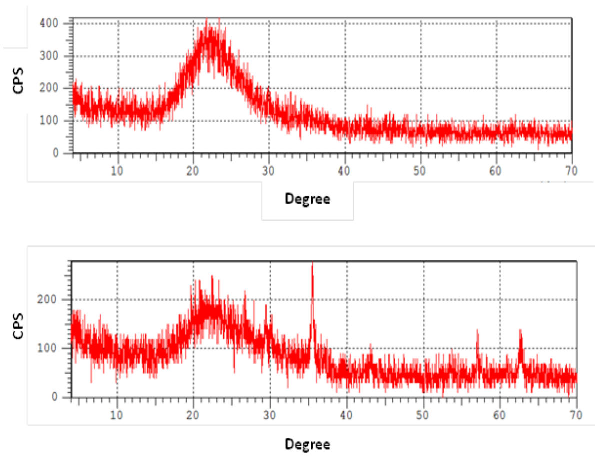

Figure 6. XRD Graph Analysis from scale samples

3.4 Scanning Electron Microscope (SEM)

Scanning Electron Microscope (SEM) is the method to identify mineral structure, mineral shape and mineral form. SEM was conducted for both samples. Sample A is the mineral with morphology spheres (ball) with size ~2 micron, sometimes it has a filament texture hollow tube with size 10 – 20 micron. The Energy Dispersive X-ray Spectroscopy analysis shows the Fe and O occurrence in the sample that might be an oxidation from the pipe line.

Sample B is also amorphous silica with morphology spheres (ball) with size ~2 micron and sometimes have a filament texture hollow tube with size 10 – 20 micron. The Energy Dispersive X-ray Spectroscopy analysis shows Si and O occurrence. Beside Silica, the occurrence of pyrite also detected

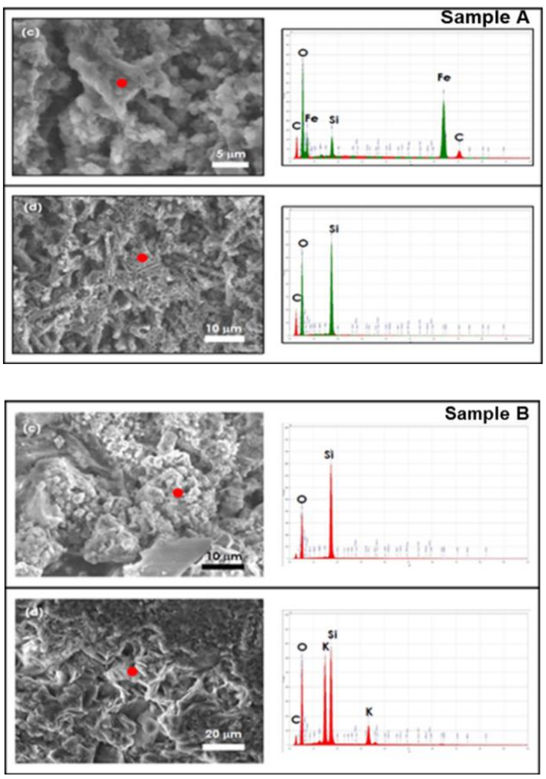

Figure 7. SEM and EDS analysis from scale samples

4. DISCUSIONS

4.1 Production Liquid Characteristics

Two wells were flowed during the long term production test after the exploration drilling completed. All wells produced near neutral (pH 6-7) benign fluid with reservoir temperature about 240 – 250°C. One of these two wells has an excess steam.

The produced brine calculated to have amorphous silica saturation temperature of 140°C for brine from ML-A1 and 110°C for brine from ML-H1 (**Figure 8**).

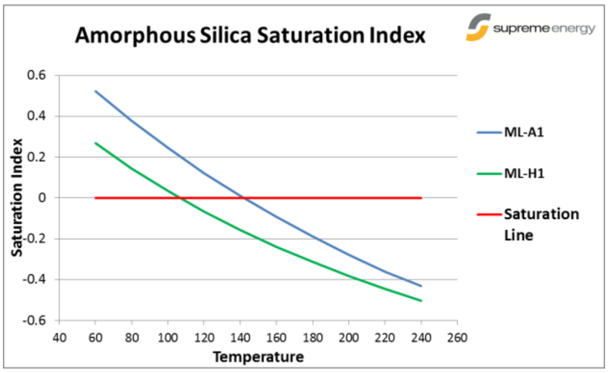

Figure 8. Scale material inside well bore injection well

4.2 Scaling Mechanism

All the analyses consistently indicate amorphous silica minerals in all the scaling materials found in the injection pipe line and injection well. The open injection system likely facilitates amorphous silica deposition. The produced brine from the production tests was flowed to central water pond near ML-A pad and then injected directly to injection well ML-E1. The produced brine temperature decreased due to contact with atmosphere temperature and mixed with rain water at the water pond, significantly cooler than the calculated silica saturation temperatures of 140 o C and 110 o C for ML A1 and ML- H1 fluid respectively.

It is expected that the brine temperature at the bottom of the water pond is cooler compared to the brine temperature at the upper part hence the bottom one is more over saturated with respect to amorphous silica. Due to the strainer located at the bottom of water pond, the cooler and heavily over-saturated brine will be injected first and has caused amorphous silica to precipitate inside the pipeline and wellbore. Figure 9 illustrates the proposed precipitation mechanism.

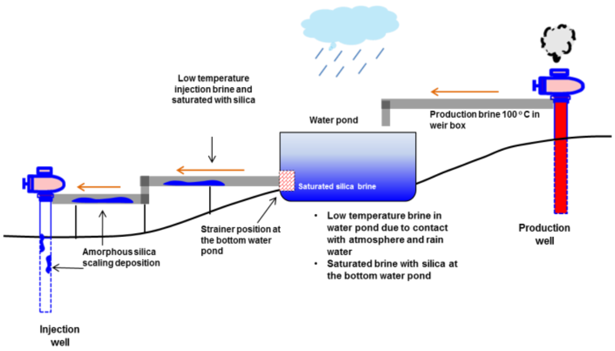

Figure 9. Scaling mechanism in pipeline injection and wellbore

5. CONCLUSION AND RECOMMENDATION

There are 3 major factors for amorphous silica scaling to form inside injection pipe line and wellbore: first is low temperature brine injection (<100°C), which is over saturated with respect to amorphous silica; second –due to lower temperature- brine is even more over saturated with silica at the bottom of water pond; and the third is the strainer position at the bottom of water pond taps the cooler brine before it deposits at the injection line.

Such open injection system will still be implemented during the production testing of the development wells hence amorphous silica precipitation is expected. One recommended way to minimize that scaling risk is to use a floating strainer in water pond. By using floating strainer the cooler brine at the bottom part will not be injected first through the pipe line and injection well. Detail position of floating strainer show at Error! Reference source not found.

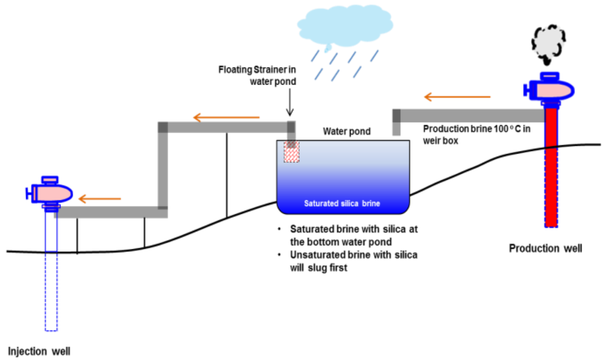

Figure 10. Floating strainer design in water pond

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