BOREHOLE TESTING OF CALCITE DISPERSION AND DISSOLUTION CHEMICALS AT TAUHARA GEOTHERMAL FIELD, TAUPO, NEW ZEALAND

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ABSTRACT

Sustainability of fluid supply to Tenon Drying Plant and Te Huka Binary Plant using three production wells located on the Tauhara Geothermal Field, Taupo, New Zealand has been hampered in the past by calcite scaling in the associated producing wells (TH06, TH14 and TH20). Two types of anti-scalant chemicals (GEO907 and GEO905) were trialled in these wells to inhibit wellbore calcite scale.

GEO907, a co-polymer of polymaleic anhydrides (PMA) and polyacrylates (PAA) commonly used in geothermal wells, was initially tested. Calcium concentrations remained higher than baseline calcium (i.e. prior to chemical treatment) since anti-scalant dosing was commenced indicating successful calcite inhibition. Supporting well output tests, Tracer Flow Tests (TFT) and downhole surveys confirmed the successful inhibition of the depositing scale. Production well output has remained steady for 2-3 years (i.e. depending on the length of time the tubing was installed) since anti-scalant chemicals were used.

GEO905, a combination of PMA and co-polymers alkyl ether polycarboxylic acid and sulfonates, was later tested due to its potential calcite dissolution properties particularly for wells partially blocked by calcite scales. In Tauhara, its effectiveness was primarily gauged in one well (TH20), which was not worked-over of calcite deposits before anti-scalant tubing was installed. The testing indicates that there could be a potential for calcite dissolution likely at higher dosing concentration (>30 ppm). The dosing rate needs to be much higher if further testing will be conducted as chelants are relatively slow in dissolving calcite scales compared to strong acids.

1. INTRODUCTION

The Tauhara Geothermal Field is located directly east of Wairakei Geothermal Field in the Taupo Volcanic Zone. There are 16 production wells and 5 injection wells drilled in this field. Two wells (TH14 and TH20) supply fluid to the 25 MWe (design capacity) Te Huka Binary Plant while TH06 provides the fluid requirement (≈200 t/h) of the Tenon Timber Drying Plant.

The Tauhara reservoir is oversaturated with calcite (Figure 1) and hence, calcite scaling in the wells has affected the production supply to these plants. Anti-scalant chemicals to control calcite scaling have been used in Tauhara wells specifically on wells where the flash point occurs within the borehole (i.e. for an effective inhibition of calcite deposition). A NALCO chemical, **GEO907**, was initially used in TH06 and subsequently utilised in TH14 and TH20. It is a co-polymer of polymaleic anhydrides (**PMA**) and polyacrylates (**PAA**) which are common components of chemical inhibitors effectively used in several geothermal fields. GEO907 is primarily a **dispersant** that attached to growing calcite crystals resulting in crystal distortion and dispersion preventing agglomeration to bigger particles. In effect, tiny calcite particles are formed and easily transported by discharging geothermal fluids.

Another NALCO chemical, **GEO905,** which has a potential for on-line calcite dissolution (Muller and Rodman, 2014) was subsequently tested in Tauhara wells. It is a combination of PMA with co-polymers of alkyl ether polycarboxylic acid and sulfonates. This chemical functions both as a dispersant (PMA) and as a **sequestrant** (co-polymers) that sequester calcium ions from borehole calcite scales (i.e. calcium is solvated through chelation).

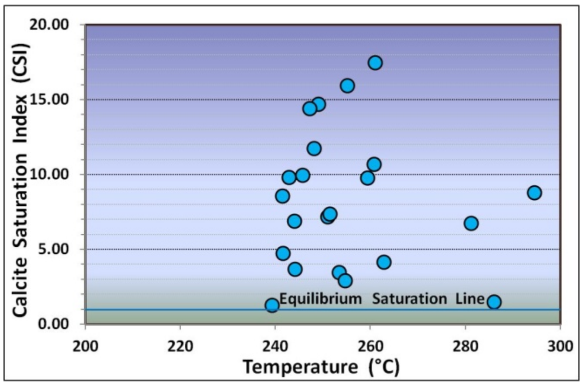

Figure 1: Calcite saturation indices of Tauhara wells simulated using WATCH Automator (Zeng *et al*., 2013).

The test results comparing dosing with GEO905 and GEO907 in Tauhara wells are discussed. The effectiveness of the anti-scalant dosing was evaluated based on fluid chemistry (calcium concentration), massflow measurements (TFT and standard bore output tests) and borehole diameter GD (Go-Devil) surveys. Economic assessment on the use of these chemicals is not covered in this paper.

2. ANTI-SCALANT DOSING WITH GEO907

Well TH06 which supplies two-phase fluid to the Tenon drying plant has undergone several mechanical workovers and acidizing since production began in May 2006 (Helbig *et al*., 2011). Historically, TH06 can sustain production for around 18 months before its massflow starts to deteriorate as a result of well bore calcite scaling.

In December 2012, a calcite anti-scalant dosing system was commissioned at TH06 after a rig mechanical work-over and acidizing. The calcite anti-scalant chemical, GEO907,

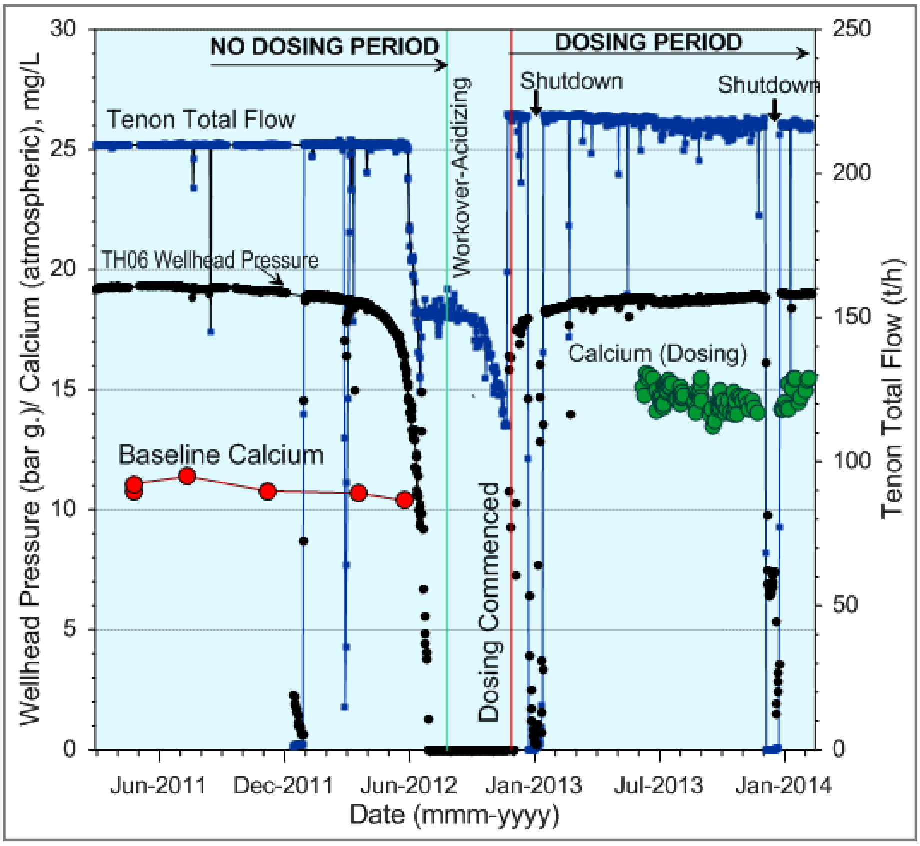

Figure 2: Comparison of TH06 wellhead pressure, calcium concentration and the Tenon Drying Plant total massflow with (GEO907) and without chemical dosing. Note: The Timber Drying Plant operation is normally shutdown during the December-January period or every year.

was initially tested for around 8 months. Calcite scaling was effectively controlled using this chemical as indicated by weirbox calcium levels consistently maintained above the baseline calcium concentration (Figure 2). Stable wellhead pressure, sustained fluid supply to the Tenon Drying Plant and physical checks such as regular gauge ring runs and on-line antiscalant tubing pull outs (i.e. under well discharge condition) have shown no indication of accumulating scale. Go Devil (GD) surveys consistently showed that the 9" gauge rings have been running to total well depth (1003 m) in the 10 ¾" production liner since anti-scalant dosing was commenced.

Based on the success of GEO907 in TH06, this chemical was subsequently used in TH14 and TH20. Similar to the test results in TH06, calcite scaling was effectively inhibited in these wells sustaining the production requirements of the Te Huka Binary Plant.

3. FIELD TESTING OF GEO905

Considering the potential advantage of using GEO905 in dissolving calcite scale (i.e. lining the inside of a wellbore) with the wells on-line for production, anti-scalant dosing was shifted to this chemical in TH06, TH14 and TH20 to replace GEO907. It was hypothesised that GEO905, being a dissolution chemical, would result in an increase in soluble calcium concentration and a corresponding increase in well massflow could occur.

Dosing with GEO905 was specifically intended for TH20 in which mechanical work-over and/or acidizing to remove calcite deposits were not undertaken before the commissioning of calcite anti-scalant dosing system. TH06 and TH14 were cleared of calcite deposits prior to any anti-scalant chemical dosing.

Significant calcite scales were detected in TH20 before the dosing system was commissioned in December 2013. This was indicated by the 6.5" diameter GD tool (November 2013) which reached only 605 m MD (Measured Depth) near the flash point in the 13 3/8" casing. The 6.0" tool, however, was run close to the well bottom at 1235 m MD within the 10 ¾" production liner.

GEO905 was programmed to be tested in TH20 at different dosing concentrations from 5 ppm to 30 ppm based on the dose rates using GEO907 as a reference. The maximum dosing concentration tested was 30 ppm (i.e. 2x the maximum GEO907 dosing rate at 15 ppm).

The test results showed that for both the GEO907 and GEO905 chemicals, the soluble calcium levels were maintained generally above the baseline concentration at a dosing rate ≥5 ppm (Figure 3). The declining Cl/Ca ratio is consistent with the increase in calcium concentration during chemical dosing. Although there was an indication in the deterioration of the calcite scale profile based on the 6.5"

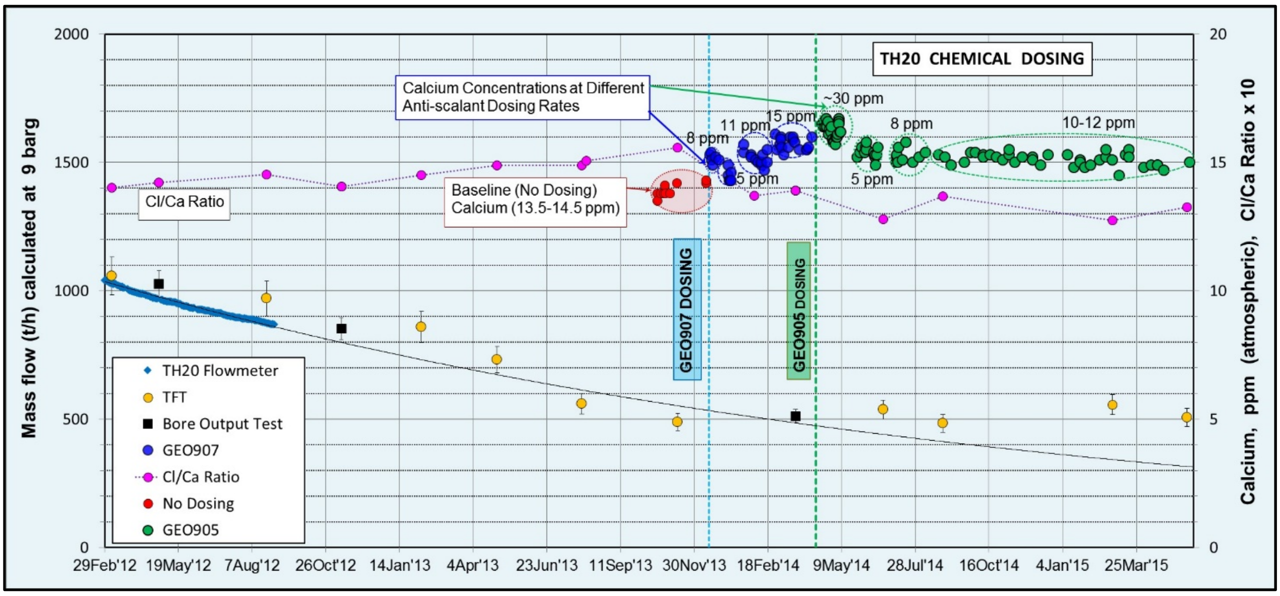

Figure 3: Comparison of massflow, calcium and Cl/Ca ratio trends of TH20 before and after calcite anti-scalant dosing. The range of uncertainties for TFT and bore output test results are indicated.

GD tool from 605 m MD (November 2013) to 517 m MD (March 2015), the 6.0" tool was still clear near the well bottom. It is not fully known when this 6.5" gauge profile deteriorated but could have occurred during periods with no dosing or dosing with less than 5 ppm. Nonetheless, there was no significant decline in the mass flows of TH20 as it has remained generally stable since chemical dosing was commenced.

It appears that there are some increases in soluble calcium with GEO905 dosing concentration at ~30 ppm in TH20 although dosing at lower concentrations (e.g., ≤15 ppm) appears to be comparable with GEO907. A comparison of the soluble calcium concentration at different dosing rates including the TH06 and TH14 chemical data confirms that GEO905 dosing performance is comparable with GEO907 particularly at lower dosing rates (Figure 4). It also shows that the dosing concentration can be reduced to as low as 5 ppm and still effectively controls calcite deposition. However, since both TH06 and TH14 were cleared of in bore calcite deposits before the anti-scalant injection, it is likely that the dosing is already close to full inhibition in these wells at 5 ppm.

Although preliminary field testing data presented by Muller and Rodman (2014) indicated promising results on the use of GEO905 based on increasing soluble calcium contents, TH20 field testing suggests that this chemical could work at higher dosing concentrations (>30 ppm). It may take much longer than the one month period (i.e. the duration that the chemical was tested at this concentration) to improve the bore output as the calcite anti-scalant dissolution rate is relatively slow compared to strong acids. Moreover, significant calcite deposits already in place in TH20 prior to chemical dosing likely hindered the dissolution of calcite at the dosing rates tested in this well.

Laboratory testing of other chelants such as Nitrilotriacetic Acid (NTA) at 38 ppm using a high temperature flow reactor indicated a dissolution rate of 0.00035 gm/ml at 250°C (maximum) for this chemical (Mella *et al*., 2006). This is consistent with the higher dosing concentration required in dissolving calcite by chelating agents due to its relatively slow dissolution rate.

4. CONCLUSION

The fluid requirements of the Te Huka Binary Plant and Tenon Drying Plant on the Tauhara Geothermal Field have been sustained for 2-3 years to date since calcite anti-scalant chemicals were used in production wells.

A co-polymer of polymaleic anhydrides and polyacrylates (GEO907) was initially utilized in the Tauhara wells and has effectively mitigated calcite scaling through particle dispersion.

An on-line calcite dissolution chemical (GEO905), which is a combination of a dispersant chemical, polymaleic anhydrides and co-polymers alkyl ether polycarboxylic acid and sulfonates, was subsequently tested. These co-polymers are sequestrants in which calcium is solvated through chelation. There is an indication of increasing soluble calcium at higher dosing rate (~30 ppm) using this chemical in TH20 although there was no corresponding increase in the bore mass output.

If further field testing will be undertaken using GEO905, higher dosing rates need to be tested particularly in wells that have substantial calcite deposits as its dissolution rate appears to be relatively slow at lower concentrations. The dosing concentration to be trialled in the wells could be based on extended laboratory testing (i.e. the maximum dosing rate that results in significant calcite dissolution rates). Ultimately, the utilisation of this chemical will depend on its effectiveness in dissolving calcite at a dosing concentration that will be economically sustainable.

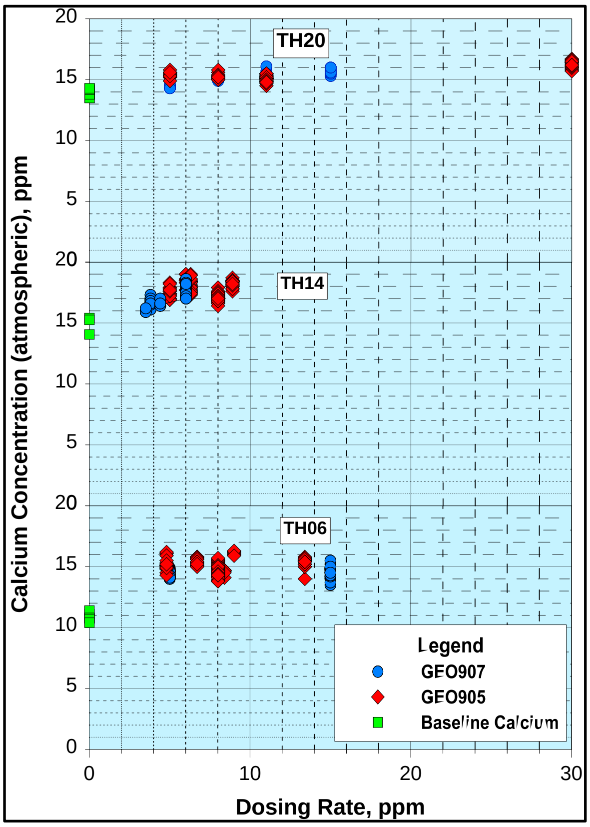

Figure 4: Soluble calcium concentrations at various anti-scalant chemical dosing rates for TH06, TH14 and TH20.

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REFERENCES

Helbig, S.J., Bixley, P.F. and Lee, S.G.: Successful acid treatment of a production well in the Tauhara field, New Zealand. Proc. New Zealand Geothermal Workshop, 21-23 November 2011, Auckland, New Zealand (2011).

Mella, M., Kovac, K., Xu, T., Rose, P. and McCulloch, J.: Calcite dissolution in geothermal reservoir using chelants. GRC Transactions, Vol.30 (2006).

Muller, L. and Rodman, D.: On line calcite removal, silica prevention and removal, NACE test and calcium acrylate prevention: an update on R&D progress. Proc. 36th New Zealand Geothermal Workshop, 24-26 November 2014, Auckland, New Zealand (2014).

Zeng, Z., Seastres, J. and Mroczek, E.: WATCH Automator: an Excel based data processor for multiple geochemical samples. Proc. 35th New Zealand Geothermal Workshop, 17-20 November 2013, Rotorua, New Zealand (2013).