Si Precipitation

Extra work was completed on the Si precipitation study. A kinetic evaluation was completed. In addition, the experiment was conducted at lower pH values. It was desired to evaluate the Si removal at lower pHs. Removal of Si at lower pH would limit the amount of basic chemicals that must be added to the geothermal brines, thereby decreasing operational costs significantly. The simulated brine formulas utilized in the Si precipitation experiments are shown in Table 1. A high and low strength brine were utilized in these experiments.

Figures 1-4 show the results for the Si experiment run at pH values of 9.0 and 10.5. Fe(+III) was added at varied Fe/Si molar ratios. The temperature was also varied for 50 and 80 ^{o}C. The results indicate that no Fe(+III) addition is necessary to meet the 80% Si removal goal for high strength brines under any of the scenarios. The pH adjustment alone meets the goal. Fe(+III) addition can enhance Si removal for the low strength brines at pH =9.0 and temperature = 80 ^{o}C and pH =9.0 and temperature = 50 ^{o}C. At pH = 10.5 and temperature = 80 ^{o}C, Fe(+III) addition decreased Si removal. At pH = 10.5 and temperature = 50 ^{o}C, no Fe(+III) addition is needed to reach to 80% Si removal goal. The pH adjustment alone reaches the goal.

Figure 5 shows a kinetic experiment conducted for the most favorable conditions (pH = 9.0, temperature = 80 ^{o}C, and Fe/Si molar ratio = 5.65 for low strength brine). The results show that the Si removal reactions occur very rapidly (<5 minutes). Hence, little retention time will be required for the process in a full scale application.

Figues 6-8 show the results for the experiment when the pH is only raised to 6.0, 7.0, and 8.0. The results show that the Si removal process will reach the project goasl pH 6.0 and 7.0 for the high strength brine when a large amount of Fe(+III) is added. At pH 8.0, less Fe(+III) (Fe/Si molar ratio ~ 2) has to be added to the high strength brine to successfully remove Si.

Table 1. Simulated Brine Formulas for Si Precipitation Experiment.

Component	Low Strength Brine Concentration (mg/L)	High Strength Brine Concentration (mg/L)
Si	10	114
Li	2	29
Na	1,700	7,466
K	232	632
Mg	20	245
Ca	20	425
SO_4	75	448
Cl	2,856	13,141

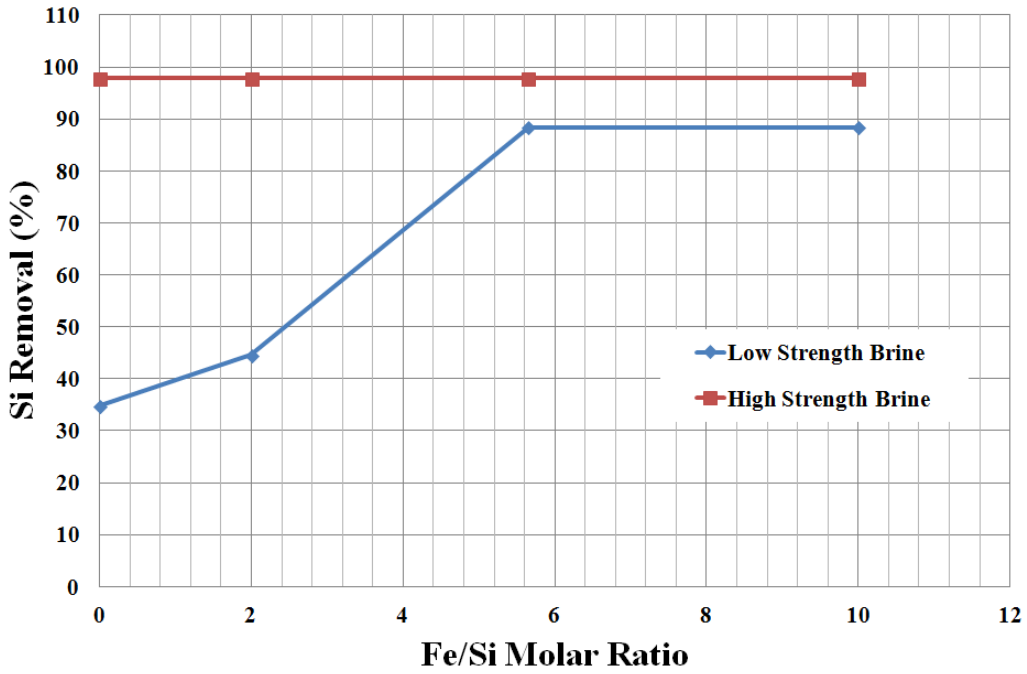

Figure 1. Si removal results for Fe(+III) addition with the pH maintained at 9.0 and temperature maintained at 80 ^{o}C.

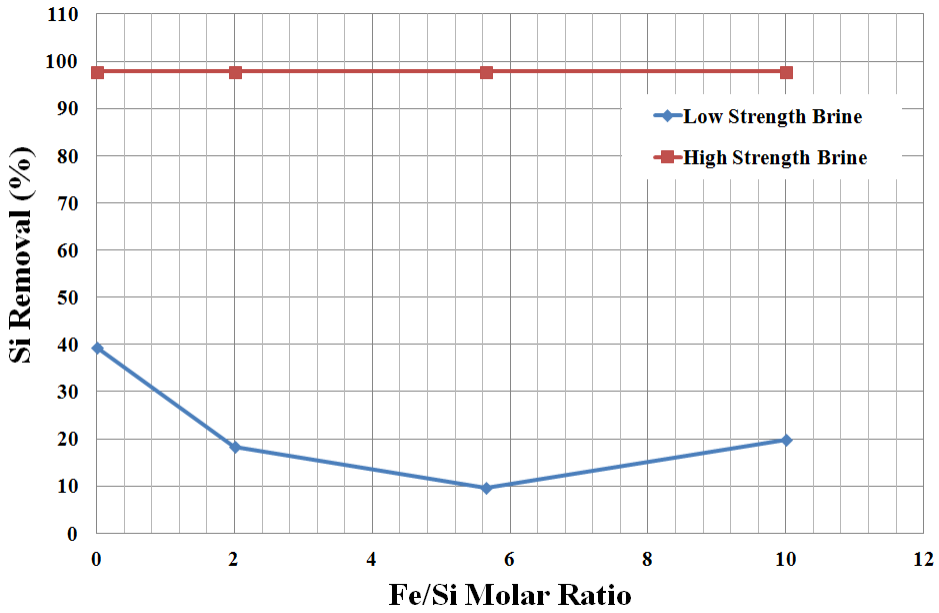

Figure 2. Si removal results for Fe(+III) addition with the pH maintained at 10.5 and temperature maintained at 80 ^{o}C.

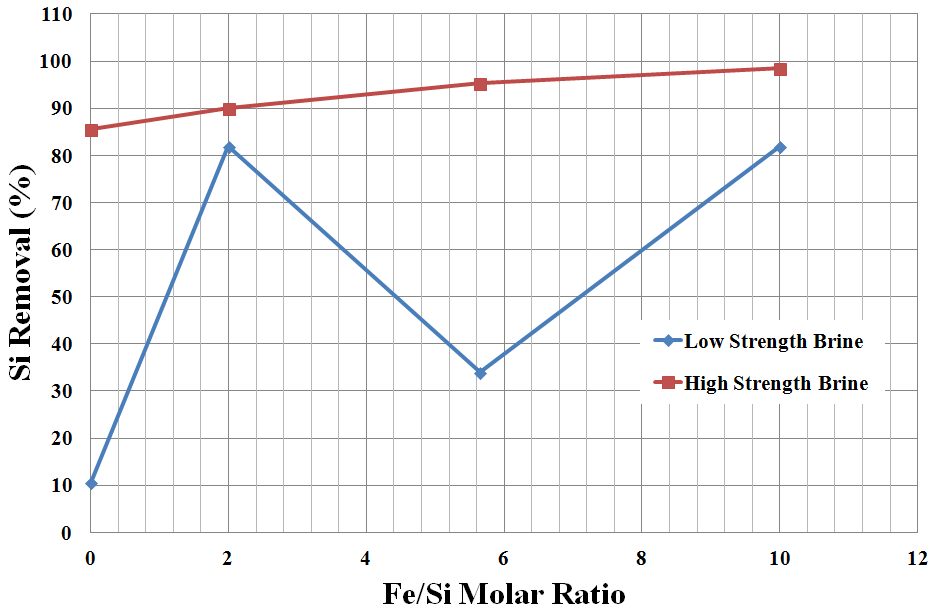

Figure 3. Si removal results for Fe(+III) addition with the pH maintained at 9.0 and temperature maintained at 50 ^{o}C.

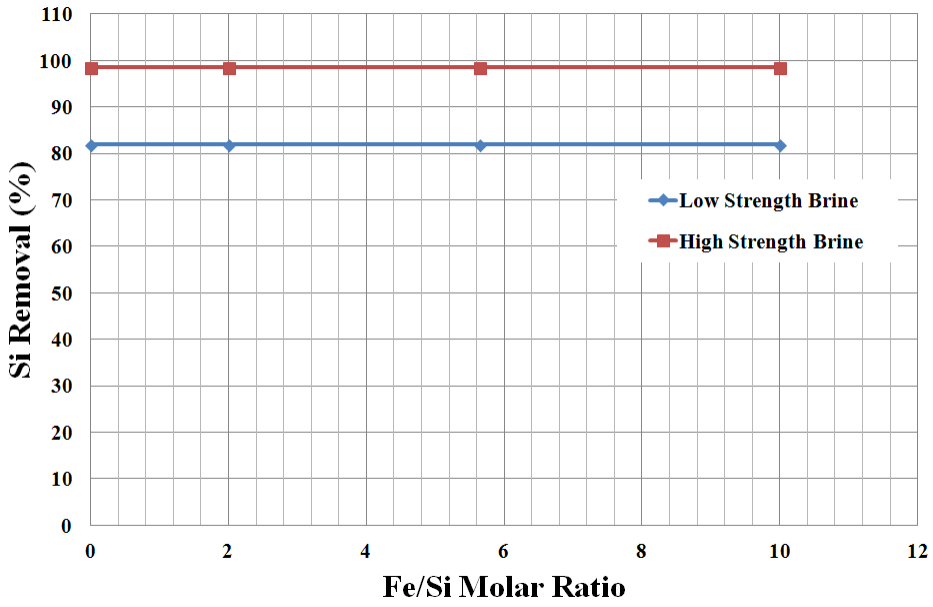

Figure 4. Si removal results for Fe(+III) addition with the pH maintained at 10.5 and temperature maintained at 50 ^{o}C.

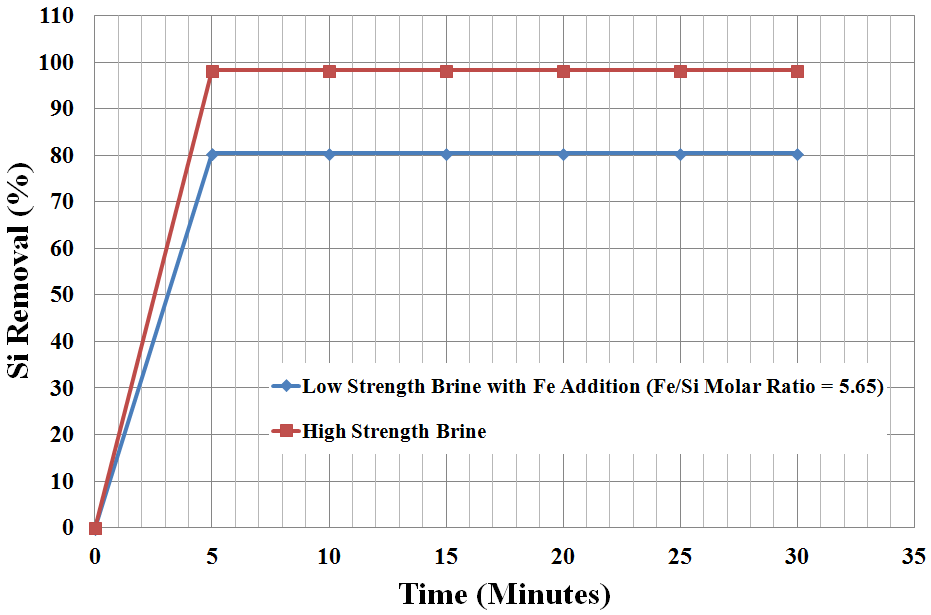

Figure 5. Kinetics of Si removal with Fe(+III) addition. pH maintained at 9.0 and temperature maintained at 80 ^{o}C. Fe/Si molar ratio = 5.65 for low strength brine**.**

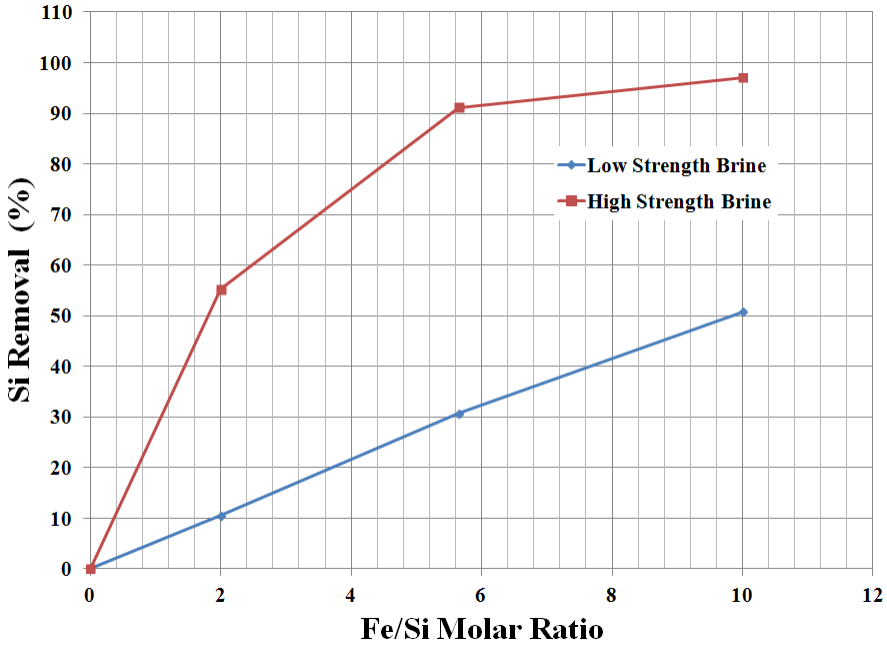

Figure 6. Si removal results for Fe(+III) addition with the pH maintained at 6.0 and temperature maintained at 80 ^{o}C.

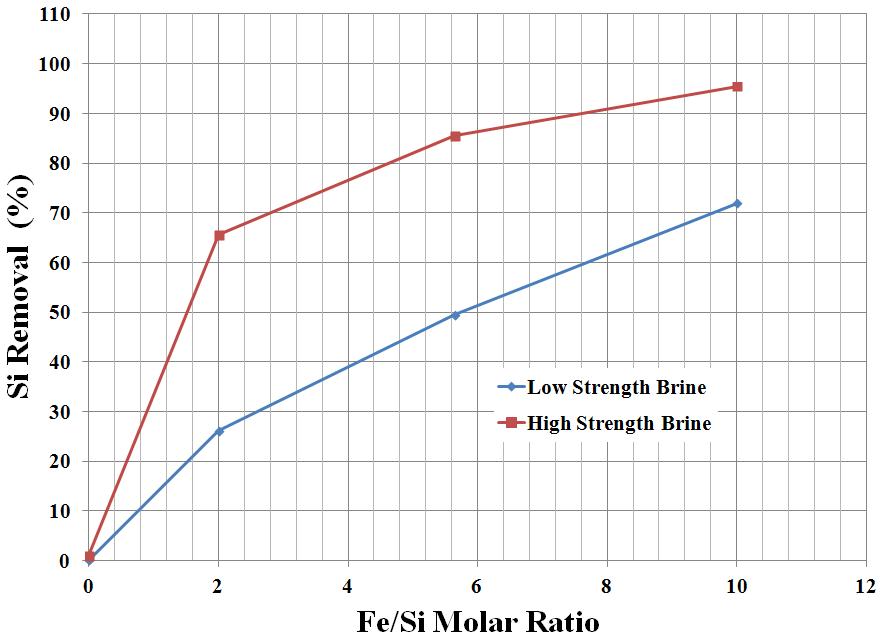

Figure 7. Si removal results for Fe(+III) addition with the pH maintained at 7.0 and temperature maintained at 80 ^{o}C.

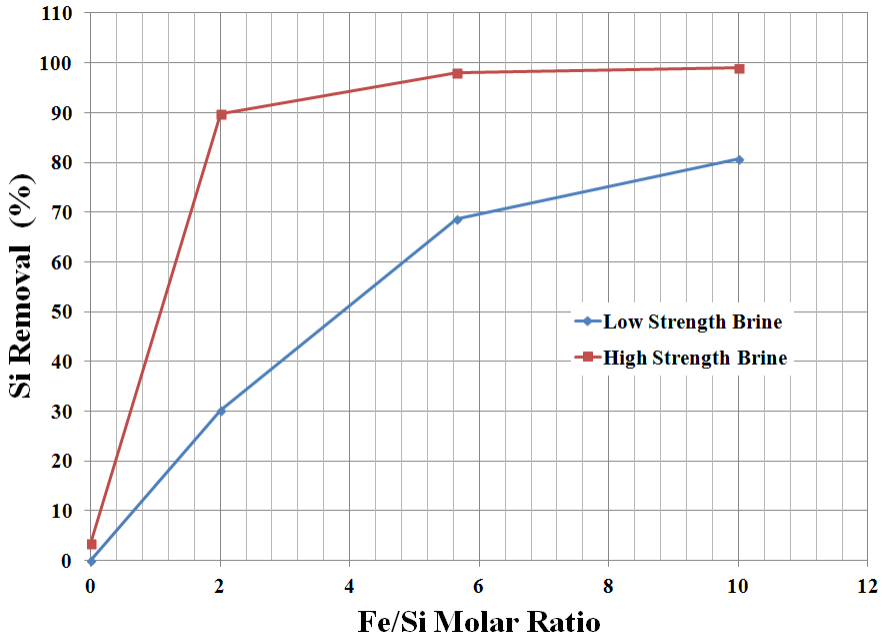

Figure 8. Si removal results for Fe(+III) addition with the pH maintained at 8.0 and temperature maintained at 80 ^{o}C.