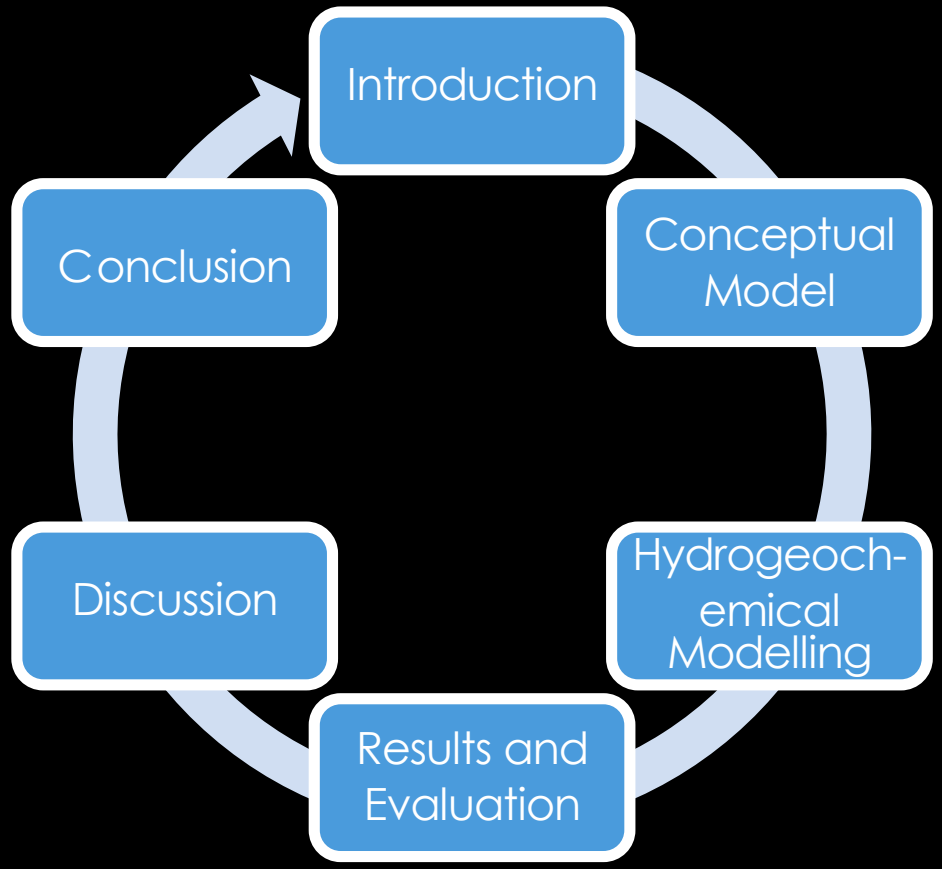
EFFECT OF MINERAL SCALING ON GEOTHERMAL WELLS

Ullas Rajvanshi

Bachelor Thesis Defense

CONTENT



Effect of Mineral Scaling on Geothermal Wells

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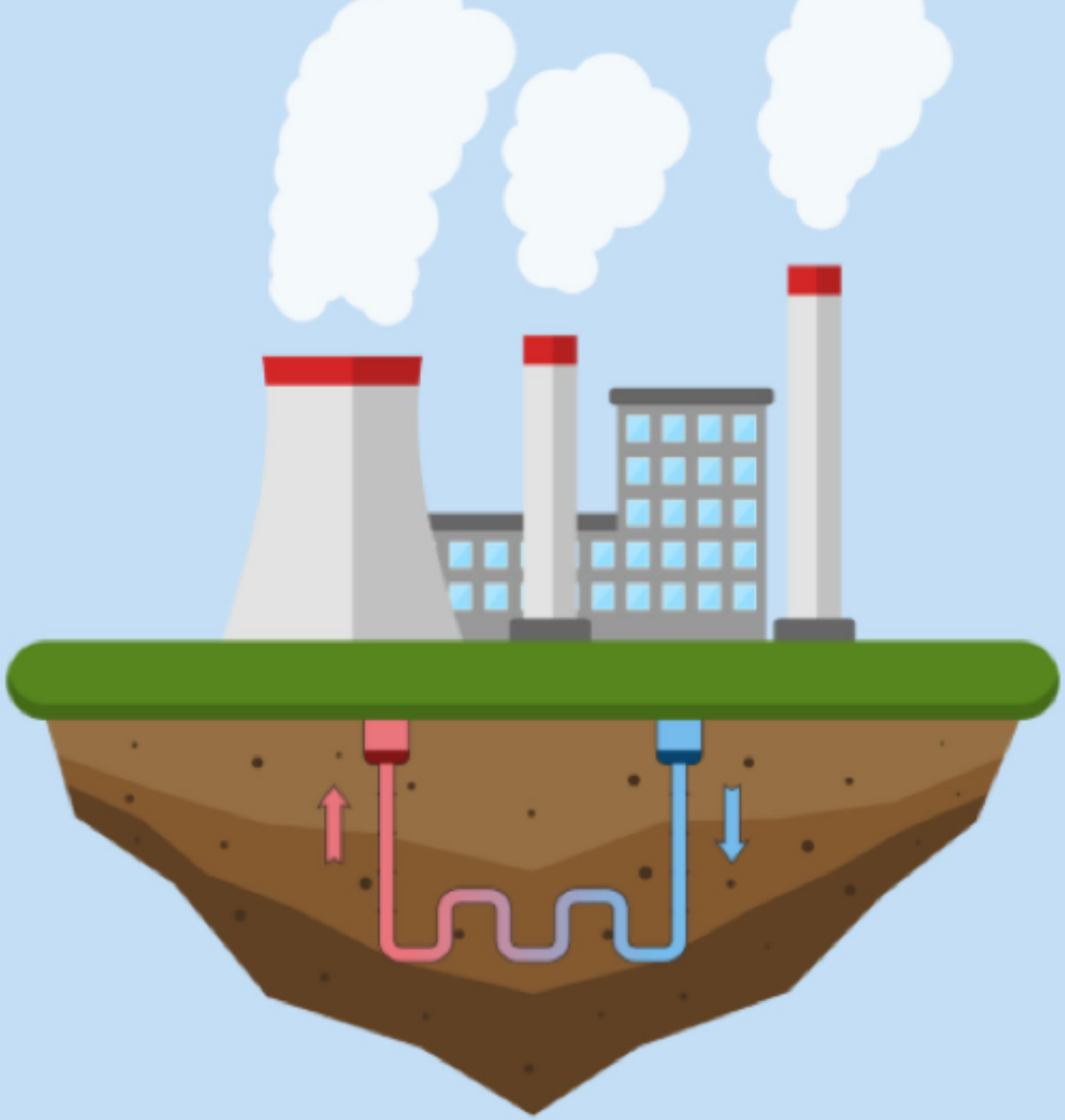
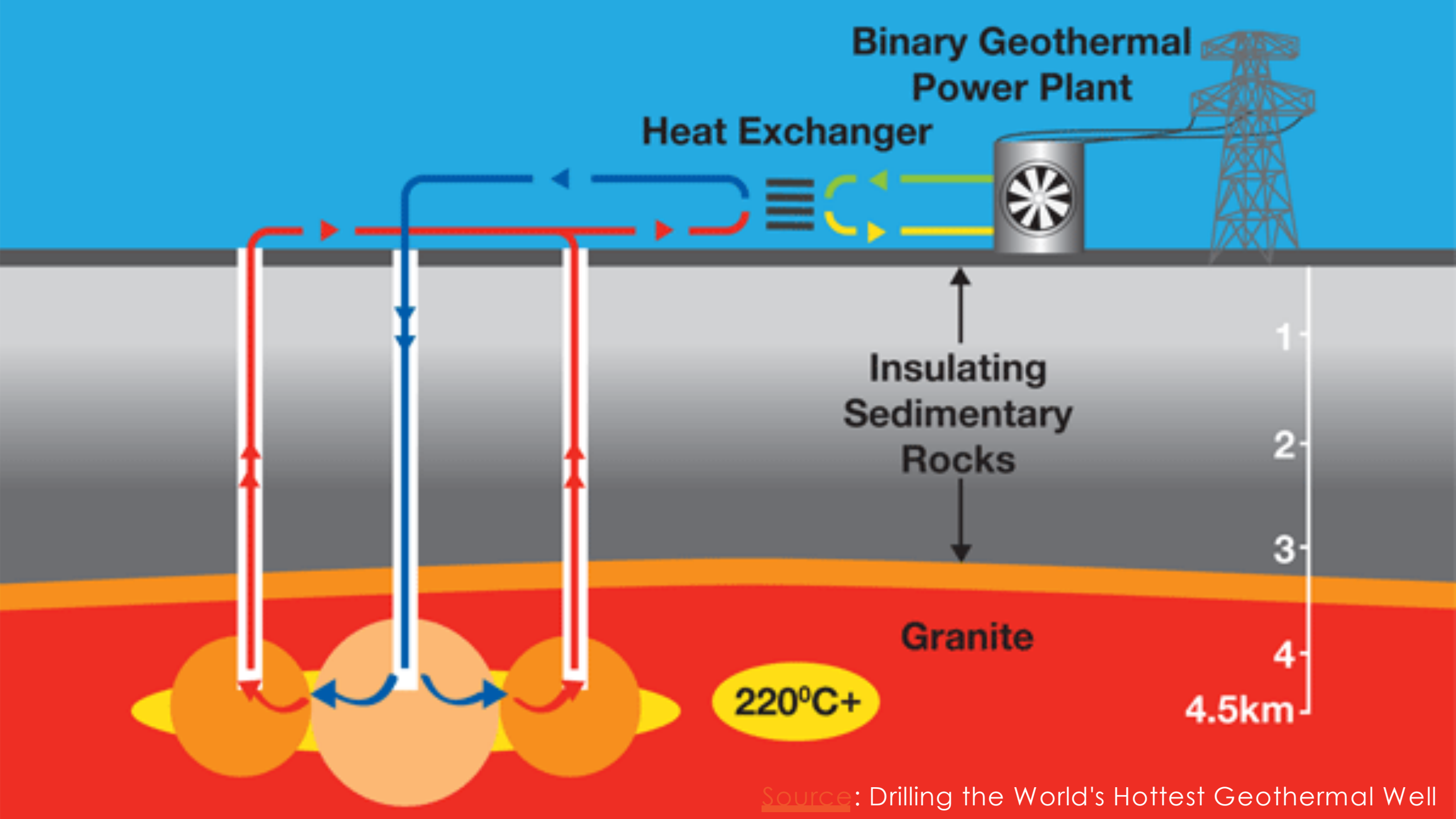
Carbonate Scaling

Available here: https://goo.gl/SUATq1

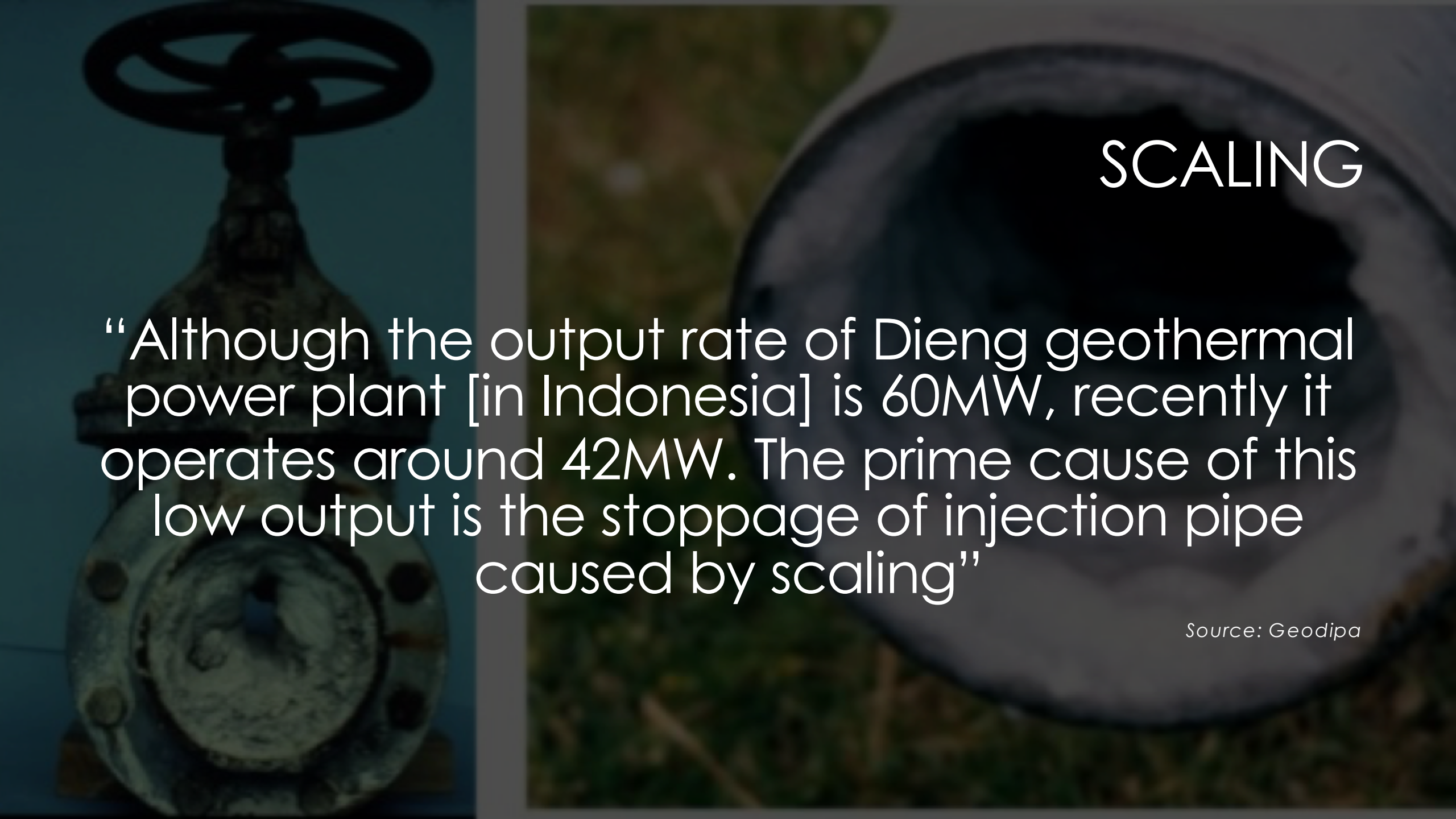
TU Delft



INTRODUCTION



Source: Drilling the World's Hottest Geothermal Well



SCALING

"Although the output rate of Dieng geothermal power plant [in Indonesia] is 60MW, recently it operates around 42MW. The prime cause of this low output is the stoppage of injection pipe caused by scaling"

Source: Geodipa

TYPES OF SCALING

- Carbonate
- Silica and Silicates
- Sulphates

CARBONATE SCALING

$$2HCO_3^- <=>> H_2O(g) + CO_2(g) + CO_3^{--}(liq.) \quad (1.1)$$

$$(Ca^{2+}).(CO_3^{2-}) = K_p \quad (1.2)$$

Ca^{2+} concentration depends upon

- Temperature
- Partial Pressure of CO_2
- Ionic Strength

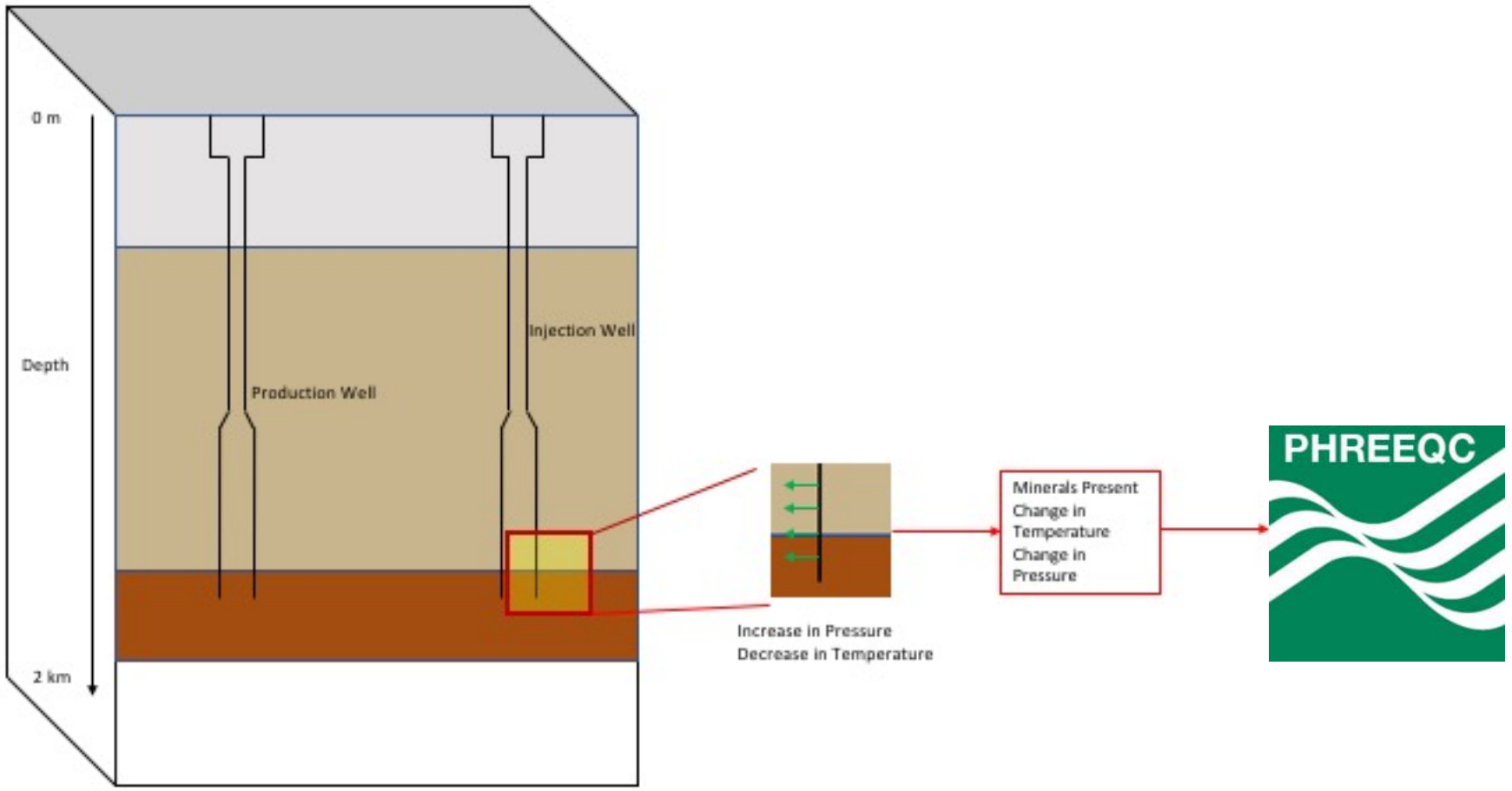
SATURATION INDEX

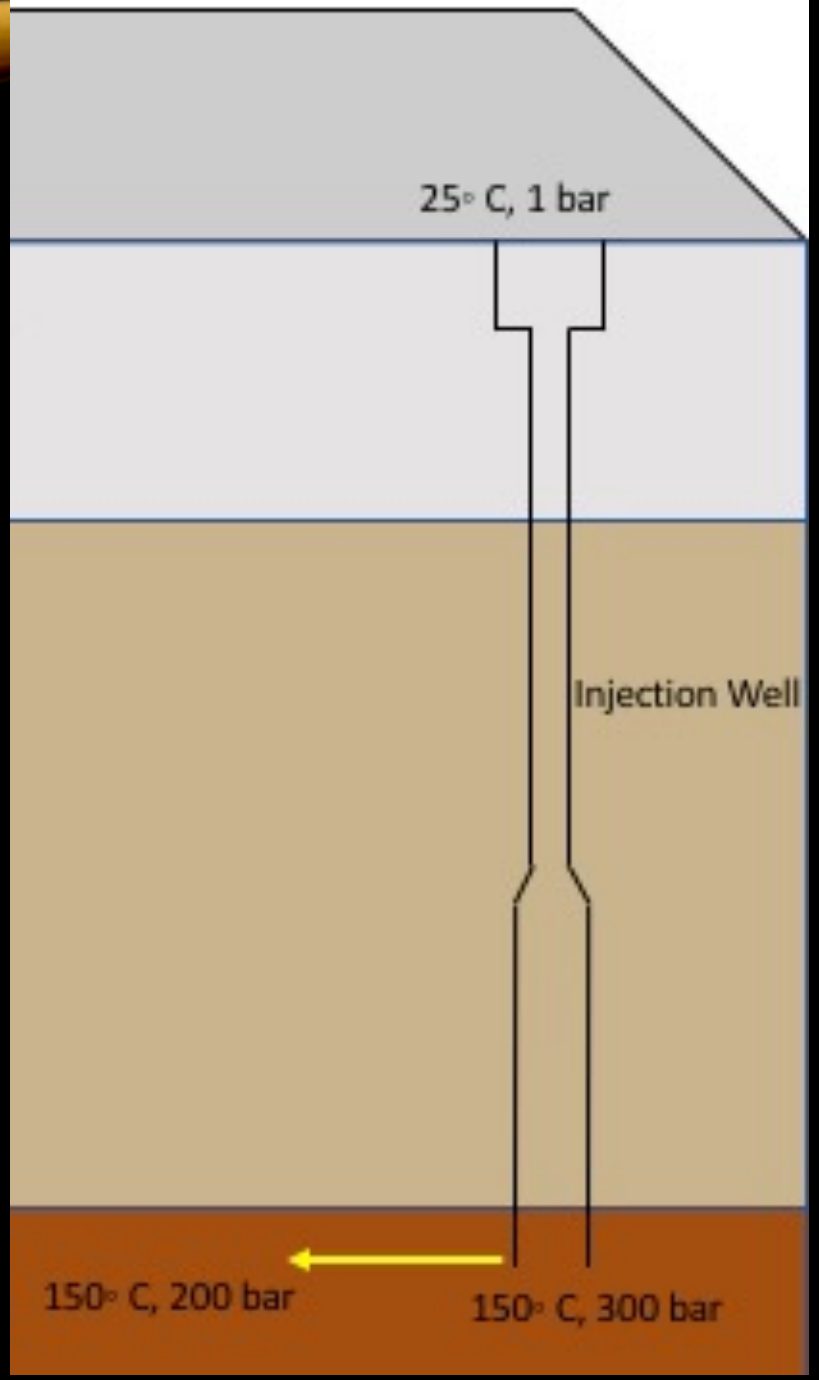
An index showing whether a water will tend to dissolve or precipitate a particular mineral. Its value is negative when the mineral may be dissolved, positive when it may be precipitated, and zero when the water and mineral are at chemical equilibrium.

PREVENTION

- Acting on CO_2 partial pressure
- Acting on pH of the solution
- Using chemical additives

CONCEPTUAL MODEL




25◦ C, 1 bar
Injection Well
150◦ C, 200 bar
150◦ C, 300 bar

Sample	Concentration (Mg/kg)
Ba	0.25
C	249.59
Ca	1350
Cl	4713 charge
K	74
Fe(2)	0.49
Li	2.44
Mg	18
Mn	1.28
Na	1670
S(6)	95.32
Sr	22
Zn	1.53
Si	1.3

HYDROGEOCHEMICAL MODELLING

```
SELECTED_OUTPUT
-file resultsobtained.sel
-step false
-reaction true
-temperature true
-pressure true
-saturation_indices Aragonite Calcite
Dolomite
```

```
SOLUTION 1 Pure water
pH 7.0
temp 25.0
EQUILIBRIUM_PHASES
Aragonite 0.0
Calcite 0.0
Dolomite 0.0
SAVE solution 1
END
```

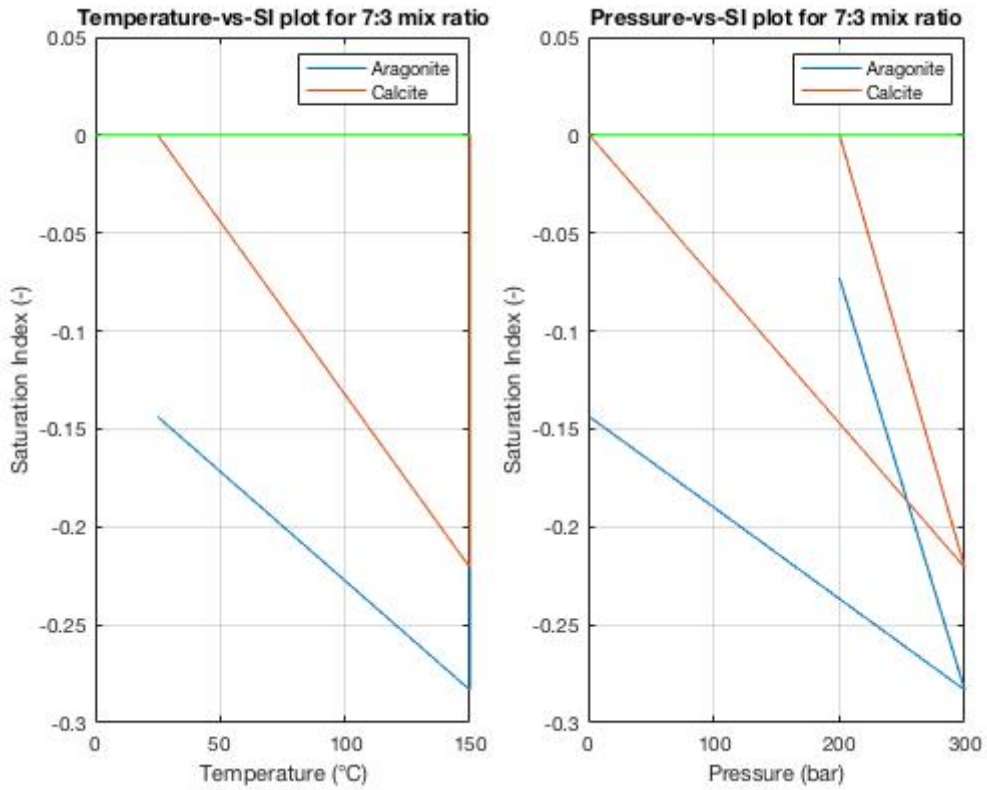
```
SOLUTION 2
temp 25
pressure 1
pH 5.7
pe 4
redox pe
units mg/kgw
density 1
Ba 0.25
C 249.59
Ca 1350
Cl 4713 charge
K 74
Fe(2) 0.49
Li 2.44
Mg 18
Mn 1.28
Na 1670
S(6) 95.32
Sr 22
Zn 1.53
Si 1.3
-water 1 # kg
SAVE solution 2
END
```

```
MIX 1
1 0.7
2 0.3
SAVE solution 3
END
EQUILIBRIUM_PHASES 1
USE solution 3
REACTION_TEMPERATURE 1
150 150 150 25
REACTION_PRESSURE 1
300 200 200 1
SAVE solution 1
END
```

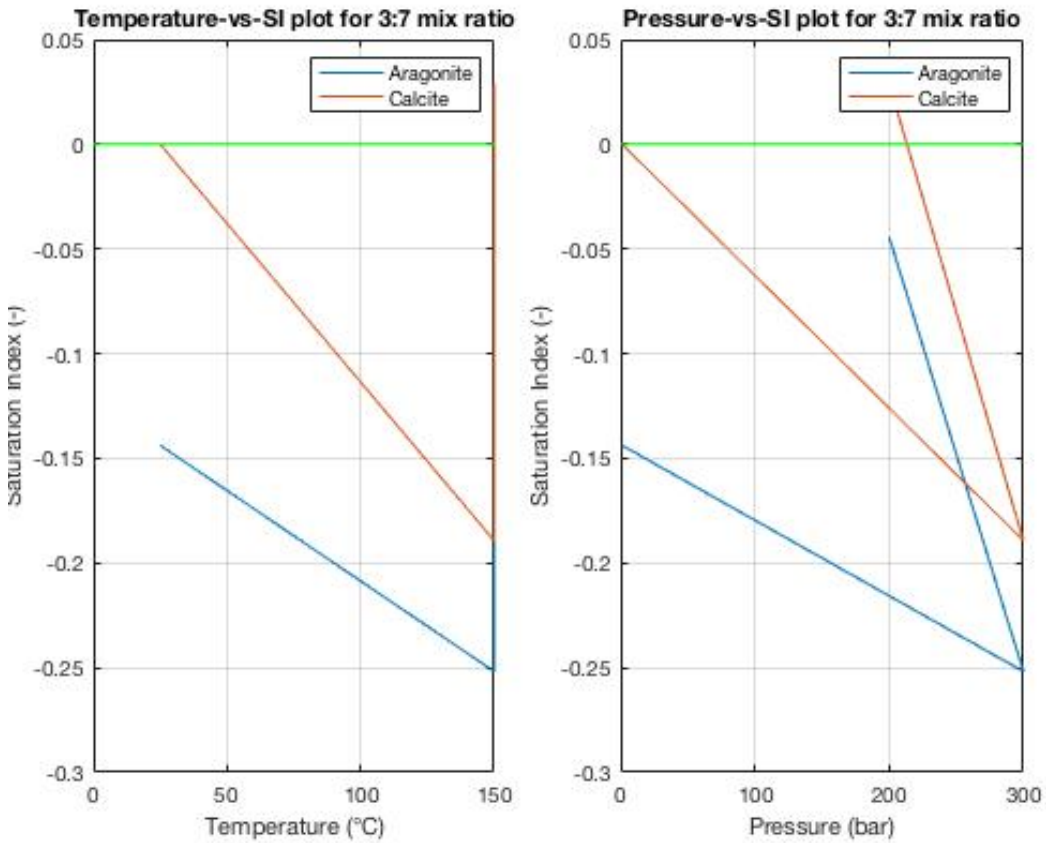
PHREEQC SIMULATION

RESULTS

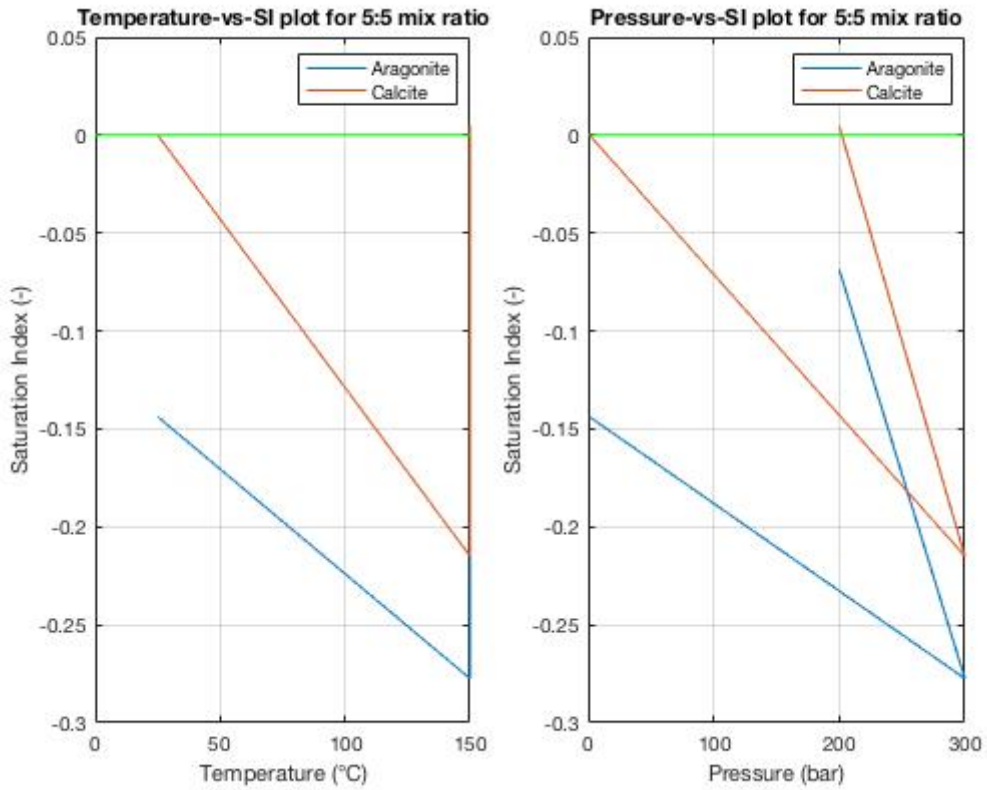
Mix #	Pure Water (%)	Brine Fluid (%)
1	70	30
2	30	70
3	50	50
4	99	1
5	1	99



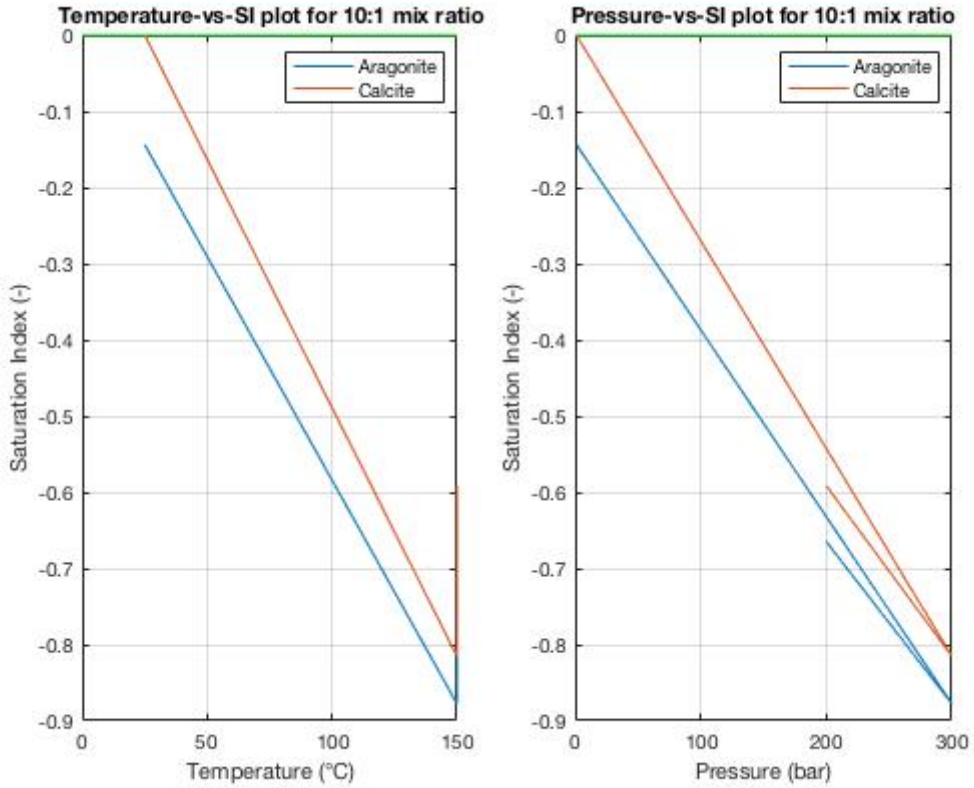
70% PURE WATER
30% BRINE



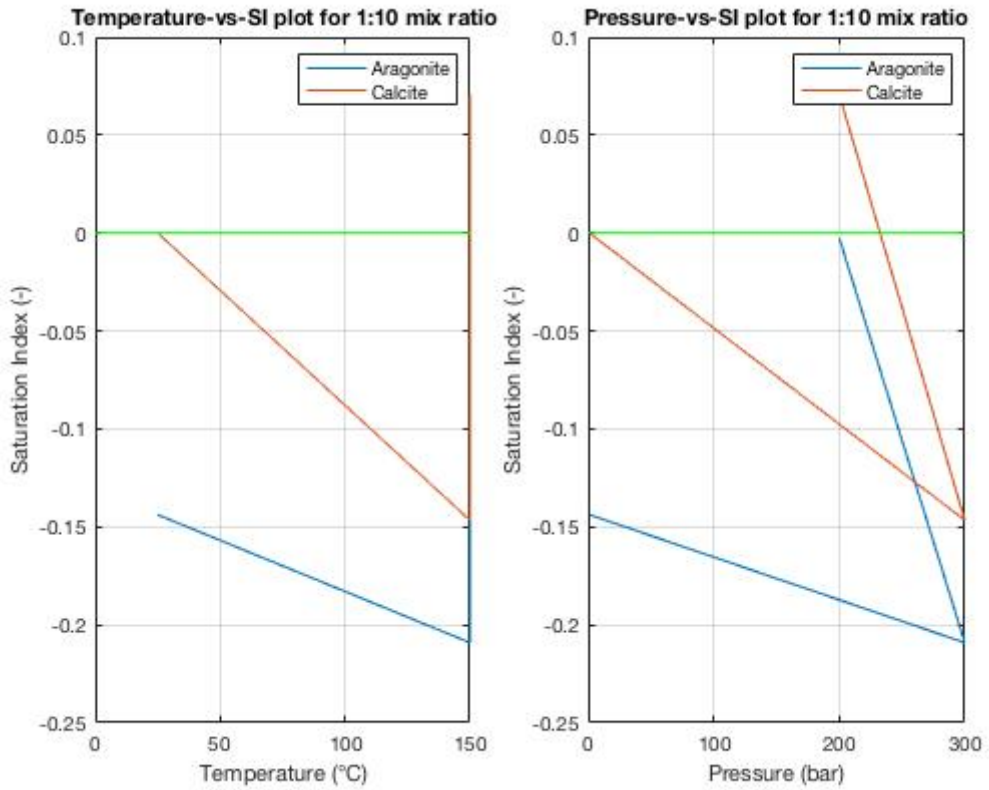
30% PURE WATER
70% BRINE



50% PURE WATER
50% BRINE



99% PURE WATER 01% BRINE



01% PURE WATER 99% BRINE

DISCUSSIONS

- Chemical Composition of the fluid.
- Considering scaling in Production Well
- Kinetics of the reaction
- Other types of scaling


That's all Folks!

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RATIO- 7:3							
soln	pH	pe	Pressure (bar)	Temperature (Celsius)	SI_Aragonite	SI_Calcite	SI_Dolomite
1	7	4	1	25	-999.999	-999.999	-999.999
1	9.97699	-4.71083	1	25	-0.1438	0	0
2	5.7	4	1	25	-1.4078	-1.2641	-4.0313
1	6.06874	-0.960122	1	25	-1.6342	-1.4904	-4.4183
3	6.12786	-3.39132	300	150	-0.2833	-0.2208	-3.1787
3	6.25578	-3.50899	300	150	-0.0727	0.0006	-2.7522
3	6.25578	-3.50899	200	150	-0.0727	0.0006	-2.7522
3	6.06874	-0.960122	1	25	-1.6342	-1.4904	-4.4183
RATIO 3:7							
soln	pH	pe	pree	temp	si_Aragonite	si_Calcite	si_Dolomite
1	7	4	1	25	-999.999	-999.999	-999.999
1	9.97699	-4.71083	1	25	-0.1438	0	0
2	5.7	4	1	25	-1.4078	-1.2641	-4.0313
1	5.79214	-0.545017	1	25	-1.5035	-1.3597	-4.2121
3	5.81555	-2.9751	300	150	-0.2518	-0.1893	-3.1702
3	5.94492	-3.09472	300	150	-0.0443	0.0289	-2.7489
3	5.94492	-3.09472	200	150	-0.0443	0.0289	-2.7489
3	5.79214	-0.545017	1	25	-1.5035	-1.3597	-4.2121
RATIO 5:5							
soln	pH	pe	pree	temp	si_Aragonite	si_Calcite	si_Dolomite
1	7	4	1	25	-999.999	-999.999	-999.999
1	9.97699	-4.71083	1	25	-0.1438	0	0
2	5.7	4	1	25	-1.4078	-1.2641	-4.0313
1	5.89043	-0.716187	1	25	-1.5735	-1.4297	-4.3359
3	5.93083	-3.12651	300	150	-0.2774	-0.2149	-3.2054
3	6.0596	-3.24568	300	150	-0.0687	0.0046	-2.7821
3	6.0596	-3.24568	200	150	-0.0687	0.0046	-2.7821
3	5.89043	-0.716187	1	25	-1.5735	-1.4297	-4.3359

soln	pH	pe	Pressure (bar)	Temperature (Celsius)	SI_Aragonite	SI_Calcite	SI_Dolomite
RATIO 10:1							
1	7	4	1	25	-999.999	-999.999	-999.999
1	9.97699	-4.71083	1	25	-0.1438	0	0
2	5.7	4	1	25	-1.4078	-1.2641	-4.0313
1	9.97699	-4.71083	1	25	-0.1438	0	0
3	7.59185	-2.69464	300	150	-0.8777	-0.8152	-3.0374
3	7.70296	-2.75269	300	150	-0.6649	-0.5916	-2.6396
3	7.70296	-2.75269	200	150	-0.6649	-0.5916	-2.6396
3	9.97699	-4.71083	1	25	-0.1438	0	0
RATIO 1:10							
soln	pH	pe	pree	temp	si_Aragonite	si_Calcite	si_Dolomite
1	7	4	1	25	-999.999	-999.999	-999.999
1	9.97699	-4.71083	1	25	-0.1438	0	0
2	5.7	4	1	25	-1.4078	-1.2641	-4.0313
1	5.7	-0.198378	1	25	-1.4078	-1.2641	-4.0313
3	5.70234	-2.82956	300	150	-0.2091	-0.1466	-3.0949
3	5.83248	-2.94956	300	150	-0.0026	0.0707	-2.6752
3	5.83248	-2.94956	200	150	-0.0026	0.0707	-2.6752
3	5.7	-0.198378	1	25	-1.4078	-1.2641	-4.0313