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Fluid Chemistry Scenarios Anticipated for IDDP-2 to be Drilled in Reykjanes, Iceland

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ABSTRACT

The Iceland Deep Drilling Project (IDDP) plans to drill well IDDP-2 to a depth of 3.5 to 5 km in the Reykjanes geothermal field, SW-Iceland. The objective of this paper is to constrain the chemical composition of the fluid that may be encountered in the well and assess the implications of the predicted fluid composition for the production properties of the fluid. The fluid composition is constrained by the following: the estimated temperature at 5 km depth, the fluid is assumed to be of seawater origin, quartz solubility over a wide range of P-T conditions and phase relations in the H_2O-NaCl system. The temperature at 5 km is estimated to be between 380°C and 550°C. The temperature estimates considered result in very different predicted fluid conditions at 5 km depth. In the lowest temperature case a single phase 3.5% NaCl fluid is expected with SiO_2 concentration of the order of 900 mg/kg. Production properties of this fluid will be similar to that of conventional high temperature geothermal solutions from this field, i.e. hot, saline, silica rich liquid that would flash upon decompression. The intermediate temperature estimate is located in the stability field of two coexisting fluid phases, i.e. brine and dilute superheated steam. The solubility of silica in the superheated steam is ~200 mg/kg assuming equilibrium with quartz. The presence of brine under these conditions depends on the P – h trajectory of the fluid on its way to this point. If superheated steam at these P – h conditions is decompressed it will condense to small degree on the way to the surface. The condensate is expected to be highly acidic and corrosive and the silica dissolved in the superheated steam is expected to partition into the liquid phase and form silica scales. Decompression of a deep brine (~10 to 20% NaCl) would result in massive deposition of NaCl, quickly rendering the production well unusable. The highest temperature estimate results in a superheated steam phase coexisting with solid NaCl. The solubility of quartz in this fluid is ~200 mg/kg. This fluid can be decompressed without condensation thus resulting in less severe casing corrosion problems than fluids from scenario 2. This fluid will, however, form silica dust upon decompression. This may result in erosion of the casing and surface pipeline. However, experience from IDDP-1 has shown that this problem can be managed by steam scrubbing at high pressure. Fluid circulation to P – h conditions above the critical point will result in massive deposition of solids. This is both because of the decreasing solubility of silica at high temperature but relatively low pressure (~300 bar), and the precipitation of most of the dissolved solids. It is therefore likely that fluid circulation to these conditions will be very limited in volume and/or time. This may limit the long term productivity of the reservoir at these P – h conditions.

1. INTRODUCTION

The Iceland Deep Drilling Project plans to drill well IDDP-2 in Reykjanes, SW-Iceland. This geothermal system has already been investigated extensively through surface exploration and 33 exploration and production wells. The deepest wells have reached beyond 3000 m depth but most wells are between 1800 and 2500 m deep. Measured down-hole temperatures are commonly around 280 to 300°C in the productive part of the reservoir but the highest recorded temperature is 350°C at the bottom of RN-30.

The geothermal fluid is thermally modified seawater (see e.g. Fridriksson et al., 2015; Friedman et al., 2009). The Cl concentration in the reservoir fluids is similar to that of seawater or around 18,000 to 20,000 mg/kg. Silica concentrations are in the range 500 to 750 mg/kg and seem to be controlled by quartz solubility (Fridriksson et al., 2015). It is anticipated that the fluid at 5 km depth in the Reykjanes system is also derived from seawater but, as will be discussed later, it is likely to be of significantly different composition from the geothermal solutions encountered at the upper levels of the system (800 to 2500 m depth).

The objective of this study is to constrain the composition of the geothermal fluid that may be encountered at 5 km depth in the Reykjanes system in order to foresee potential production problems that may result from the utilization of this fluid. The physical state and consequently composition of the geothermal fluid at that depth depends on the temperature and pressure conditions. The fluid composition scenarios investigated in this study are constrained by estimates of the maximum and minimum temperature expected at 5 km.

2. TEMPERATURE SCENARIOS

The expected temperature at 5 km depth in the Reykjanes system was constrained using observed temperature gradients at the bottom of the deepest production wells and the location of the brittle/ductile boundary in Reykjanes inferred from the paucity of seismic activity. Figure 1 shows temperature profiles for wells RN-12, 15, 17B, and 30. The profiles shown on the figure represent measured temperatures down to 2500 to 2700 m depth. Most production wells in Reykjanes have more or less vertical temperature/depth profiles, similar to that of RN-15 (Figure 1), due to effective convection in the geothermal reservoir. However, some of the deeper production wells (e.g. RN-12) and the marginal low-permeability wells (RN-17B and RN-30) have a conductive character towards the bottom. The conductive part of the temperature profiles of wells RN-12, 17B, and 30 have been extrapolated to 5 km depth in Figure 1.

Extrapolation of the near-bottom part of the temperature profiles of wells RN-12, 17B, and 30 yields temperatures of 382, 441, and 395°C, respectively, at 5 km depth. The temperature value thus obtained for RN-12, 382°C, is taken to represent the minimum temperature estimate at 5 km depth. The highest temperature value obtained by extrapolation of bottom hole thermal gradient, i.e. the 441°C at 5 km depth for RN-17B, was considered as an intermediate potential temperature at 5 km depth.

The highest temperature estimate was obtained by using the observed maximum depth of earthquakes in and around Reykjanes as an indication of the brittle-ductile boundary. Most earthquakes in and around the Reykjanes geothermal system occur above 5 km depth although focal depths of down to ~6 km are reported (Klein et al., 1977; Gudnason and Ágústsson, 2014). Ágústsson and Flóvenz (2005) argued that the cessation of seismic activity in the Icelandic crust could be taken to correspond to a temperature of 600 to 800°C. Accordingly a temperature as high as 700°C could be assigned to 5 km depth below Reykjanes. This was considered excessive and a more conservative approach was taken by assigning 700°C to 7 km depth and interpolating that temperature to the extrapolated bottom hole gradient in RN-17B at 3500 m depth. The resulting temperature of 550°C was used as the maximum temperature expected at 5 km at Reykjanes. Below it will be demonstrated that the consequence of selecting 550°C over 700°C as the temperature at 5 km will not have a fundamental consequence on the resulting predictions on fluid chemistry.

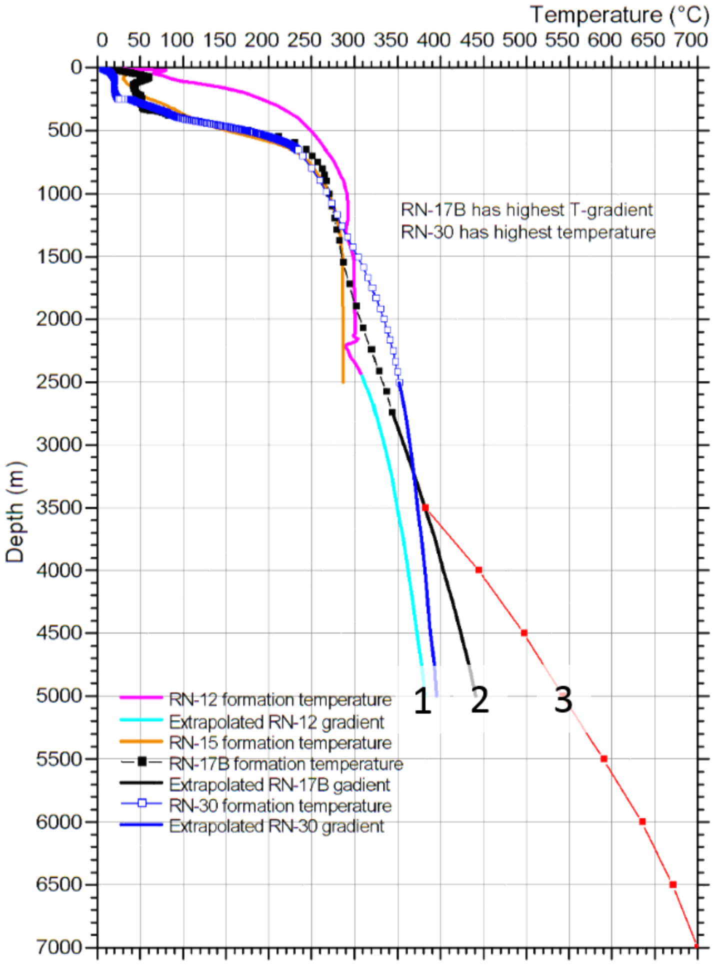

Figure 1: Temperature profiles in selected wells in Reykjanes. The vertical profile of RN-15 is characteristic of the production wells in the Reykjanes system. Thermal gradients near the bottom of wells RN-12, 17B and 30 are extrapolated to 5 km depth (blue and black curves). The red curve represents an interpolation between 700°C at 7 km depth and the temperature obtained at 3.5 km by extrapolation of the bottom hole thermal gradient in RN-17B. The numbers 1, 2, and 3 refer to the minimum, intermediate and maximum temperature estimate at 5 km, which are used to constrain the expected chemical scenarios.

3. APPROACH

In this study we explore the chemical implications of the three potential deep temperature scenarios (Figure 1) on a phase diagram for H_2O constructed in terms of pressure from 0 to 500 bar and enthalpy from 0 to 3500 kJ/kg shown in Figure 2. Quartz solubility (Fournier and Potter, 1982) over the entire pressure-enthalpy range is superimposed on the phase diagram as concentration contours. Phase relations in a NaCl-H_2O system with 3.5% NaCl are also shown on the diagram. The NaCl-H_2O phase relations were constrained using the sowat_ptx.exe code (Driesner and Heinrich, 2007; Driesner, 2007). The Water97_v12.xla (Spang, 2000) was used to compute the properties of H_2O at elevated pressure and enthalpy (temperature). This software is consistent with the IAPWS-IF97 formulation for thermodynamic properties of H_2O.

Figure 2 shows how the silica concentration controlled by quartz solubility increases with increasing enthalpy, irrespective of pressure at the lower enthalpies, up to about 1500 kJ/kg. At higher enthalpies the quartz solubility decreases in response to decreasing density of the fluid phase. Above ~2500 kJ/kg the quartz solubility is more sensitive to pressure than the enthalpy.

Figure 2 also shows how the 3.5% NaCl-H_2O system is a single liquid phase up to about 2450 to 2500 kJ/kg. At enthalpies above 2800 to 3400 kJ/kg the system consists of vapor and solid NaCl (halite). In between these fields is a wedge where two fluid phases, high NaCl, high density brine, and dilute, low density fluid, coexist.

The three potential temperature scenarios shown in Figure 1 are projected onto Figure 2. Inspection of Figure 2 reveals that the three temperature scenarios are located in the three different fields of the NaCl-H_2O phase diagram. The minimum temperature scenario (1), assuming a temperature of 382°C (1830 kJ/kg) at 5 km depth is located in the single liquid field. The intermediate temperature scenario (2) assuming a temperature of 441°C (2740 kJ/kg) at 5 km is located in the brine-dilute fluid field. Finally, the highest temperature scenario assuming 550°C (3256 kJ/kg) at 5 km is located in the vapor-halite field. This has profound implications for the anticipated properties of the fluids, which are explored below. Alternative recharge paths in pressure-enthalpy space by which the fluids reach the conditions at 5 km depth are also considered for scenario 2 and 3. The implications for production properties of the three temperature scenarios are explored below.

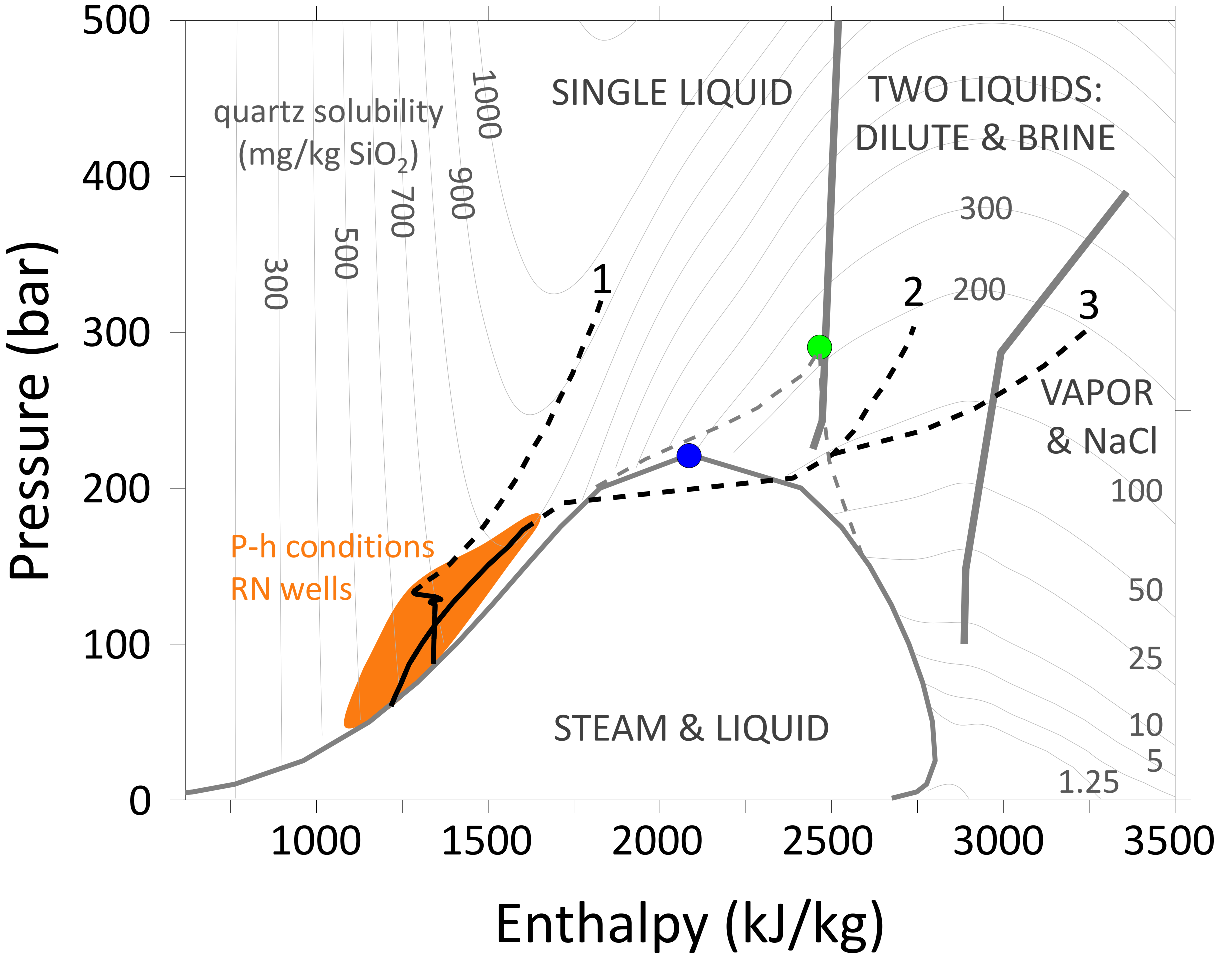

Figure 2: Phase diagram for H_2O in terms of pressure and enthalpy with superimposed quartz solubility (gray contour lines) and phase boundaries in a 3.5% NaCl-H_2O system (single liquid, dilute fluid/brine, and vapor/solid NaCl). The critical points for pure water and seawater are shown by blue and green symbols, respectively. The P-h conditions of the current Reykjanes production wells is indicated by an orange field. The hatched curves indicate the extrapolated temperature curves shown on Figure 1, representing the three temperature scenarios considered in this study.

4. SCENARIO 1

Figure 3 shows a potential recharge path (A) and a production path (B and C) for temperature scenario 1. The recharge scenario indicated by the red curve extends from the pressure-enthalpy conditions in the Reykjanes production field. It can be seen from the figure that quartz solubility increases continuously along this recharge path. The implication is that a geothermal fluid could travel along this path without precipitating quartz along the way. This means that permeability is conserved along the fluid flow path.

The green and blue arrows, labelled B and C, indicate the path of the fluid upon production. If temperature scenario 1 applies to the conditions encountered at 5 km in the IDDP-2 well the fluid will decompress adiabatically (i.e. at constant enthalpy) upon production along path B until the steam-liquid field is encountered at ~200 bar. At that point the fluid will flash and form steam as indicated by the C arrow. Upon further pressure reduction the flashing will continue until the steam is separated from the liquid at the surface.

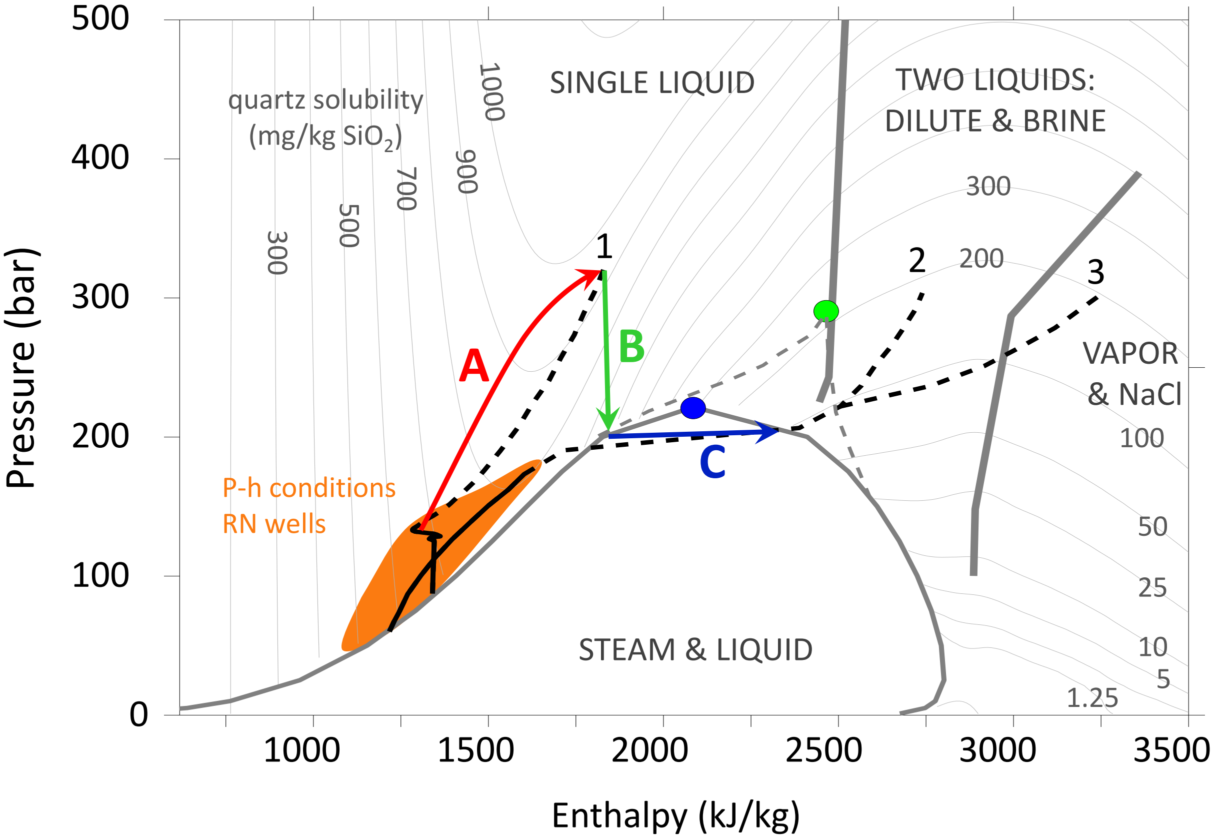

Figure 3: Phase diagram for H_2O shown in Figure 2, with added potential fluid recharge path (A) and production paths (B and C) of scenario 1 fluid.

If the temperature conditions in the IDDP-2 well will be in accord with temperature scenario 1 shown in Figure 3 the production properties of the fluid will be largely similar to the geothermal fluids currently produced from the Reykjanes reservoir, albeit with some complications. The silica concentration of the fluid will be somewhat higher than what is the case in the currently produced fluids. The figure shows that the expected silica concentration in the IDDP-2 fluid assuming scenario 1 will be around 900 mg/kg, compared to 500 to 750 mg/kg in the reservoir fluids produced from the current production field (Fridriksson et al., 2015). Upon flashing the liquid phase would reach saturation with respect to amorphous silica at around 275°C and 60 bar (using the amorphous silica solubility from Fournier, 1977) at which point the steam fraction would be 0.4. Metal sulfide scaling already occurs in the Reykjanes production wells and surface equipment (see e.g. Hardardottir et al., 2010) and this is expected to be even more pronounced in the IDDP-2 well if it encounters fluids with temperatures of the order of 380°C (scenario 1) due to prograde solubility of sulfides.

5. SCENARIO 2

The intermediate temperature scenario (2) is the most complex from the perspective of predicting the fluid chemistry and the least favorable from the perspective of production. Figure 4 shows two potential fluid recharge paths for scenario 2, labelled A and A*, and the production path (B and C) on the phase diagram. The two recharge pathways represent two fundamentally different scenarios that will have profound implications for the anticipated fluid chemistry.

5.1 High pressure recharge pathway

The higher pressure recharge path (A) passes above the critical point which means that boiling will not occur along the way. However, assuming a total salinity of 3.5%, the fluid will separate into two fluid phases just above the critical point for that salinity. Most of the mass will be in a dilute fluid phase whereas some of the mass will be in a brine phase with up to 20% NaCl content. The density of the dilute phase is also much lower than that of the brine so the volume ratio of the two fluids will further tilt towards the dilute phase. Inspection of Figure 4 reveals that the silica concentration of the dilute phase will be around 200 mg/kg, or significantly lower than that of the geothermal fluids in the Reykjanes production wells. This suggests that recharge along this path will result in quartz precipitation along the way, resulting in some loss of permeability. The silica solubility of the high salinity brine has not been assessed but it is likely to be higher than that of the more dilute phase due to high density of the brine.

The production properties of the two possible fluid types will be very different but it seems inevitable that both will be very problematic. The production properties of high enthalpy brine with up to 20% NaCl are not fully understood. However it seems likely that production of this fluid will lead to serious corrosion problems in the well and surface equipment. The production properties of the dilute phase seem more predictable. If dilute fluid would be encountered in IDDP-2 at a temperature corresponding to scenario 2, the adiabatic decompression of the fluid upon production would follow the green arrow in Figure 4 (B) until it would encounter the two phase field for the H_2O system. At that point condensation would occur as indicated by the blue arrow (C). The dissolved HCl in the dilute fluid would partition preferentially into the condensate. If condensation would occur inside the well this would result in acute corrosion problems at the point of condensation. Furthermore, other dissolved solids, including silica, would also partition into the condensate potentially resulting in rapid clogging of the well or its feeding aquifers.

5.2 Low pressure recharge pathway

The low pressure recharge pathway (A*) for temperature scenario 2, shown in Figure 4 passes below the critical point. This means that the fluid will boil along the way, leaving behind the non-volatile dissolved constituents. In this case the fluid encountered at 5 km depth in the IDDP-2 well will be essentially superheated steam. This phase will have some amount of geothermal gases, i.e. CO_2 and H_2S and ~200 mg/kg of SiO_2. It is also likely that the concentration of HCl in this phase will be significant considering that it will be formed by boiling of saline liquid at high pressure.

The production properties of the scenario 2 superheated steam would be similar to those of the dilute fluid discussed in section 5.1 above, i.e. the steam would condense on the way to the surface and the first condensate can be expected to be extremely acidic due to HCl partitioning into the condensate. On the other hand, solid precipitation would likely be less of a problem in this case. However, because the low pressure recharge pathway (A*) will involve massive precipitation of dissolved solids when the geothermal fluid passes through the two phase field it seems unlikely that significant production could be sustained for a long time under these conditions.

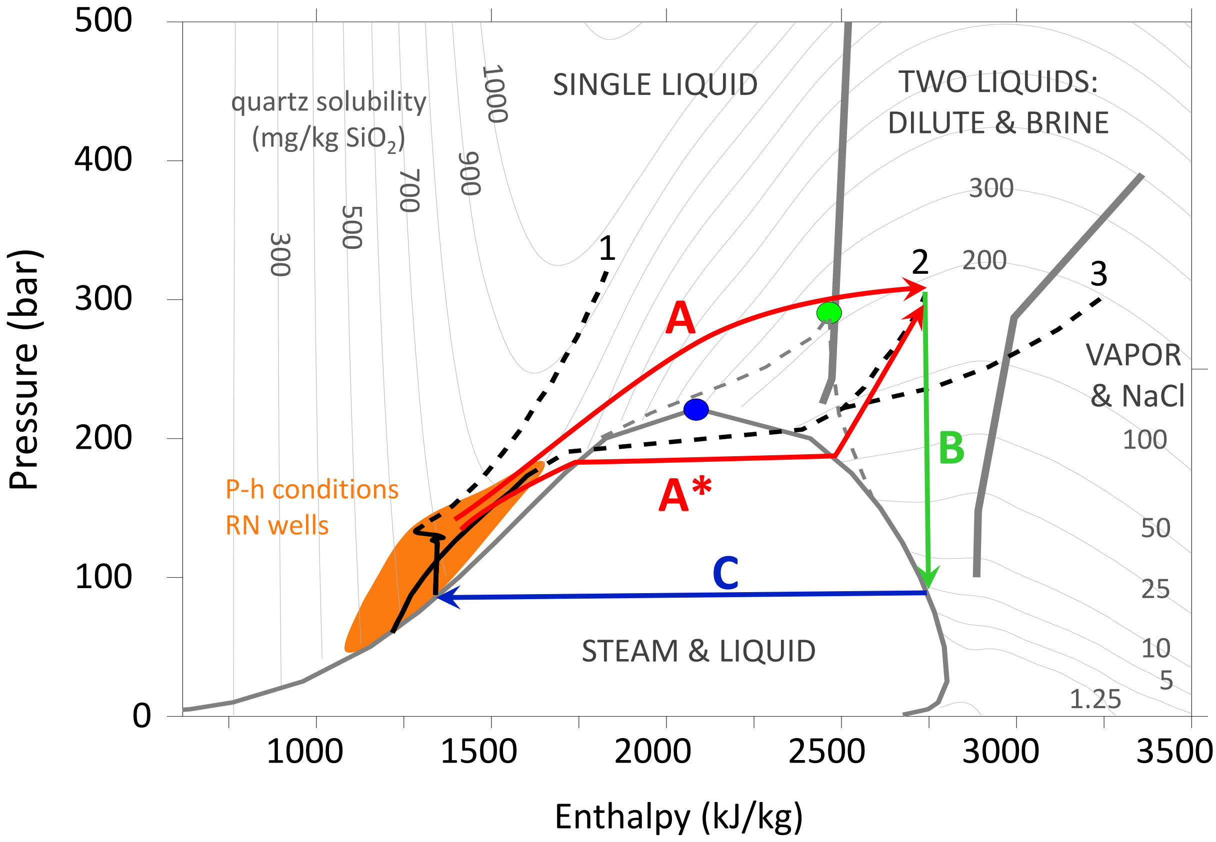

Figure 4: Phase diagram for H_2O shown in Figure 2, with added potential fluid recharge paths (A and A*) and production paths (B and C) of scenario 2 fluid.

6. SCENARIO 3

Potential fluid recharge pathways and the production pathway for the high temperature scenario 3 are shown in Figure 5, below. The two recharge pathways, labelled A and A* in Figure 5, are essentially the same as in Figure 4 for the intermediate temperature scenario (2), i.e. A passes above the critical point and A* passes below it. However, the different recharge pathways have less significant implications for the properties of the scenario 3 fluid than in the case of scenario 2. In both cases the fluid encountered under scenario 3 conditions is expected to be superheated steam. In the case of the low pressure recharge pathway, A*, the dissolved solids will be lost from the fluid at the point of boiling (see section 5.2). In the case of the high pressure recharge pathway, A, on the other hand, the dissolved solids are lost from the fluid when it passes into the vapor-NaCl field of the phase diagram.

The superheated steam encountered at 5 km depth in the IDDP-2 well, assuming temperature scenario 3, will have ~200 mg/kg of silica and a significant concentration of HCl. The production pathway of this fluid is indicated by the green arrow, labelled B in Figure 5. Inspection of the figure reveals that during adiabatic decompression the fluid will not encounter the two phase field of the H_2O phase diagram. This means that the fluid can be brought to the surface as superheated steam similar to what was experienced in the IDDP-1 well in Krafla (Ármannsson et al., 2014; Hauksson et al., 2014). The benefit of this is that the HCl will not cause corrosion of the casing as the steam passes up the well. Once at the surface, the fluid can be treated to neutralize the HCl (see Hauksson et al., 2014). The silica dissolved in the steam can be expected to precipitate as amorphous silica dust (Ármannsson et al., 2014) but wet scrubbing of the steam at the surface can also alleviate this problem (Hauksson et al., 2014).

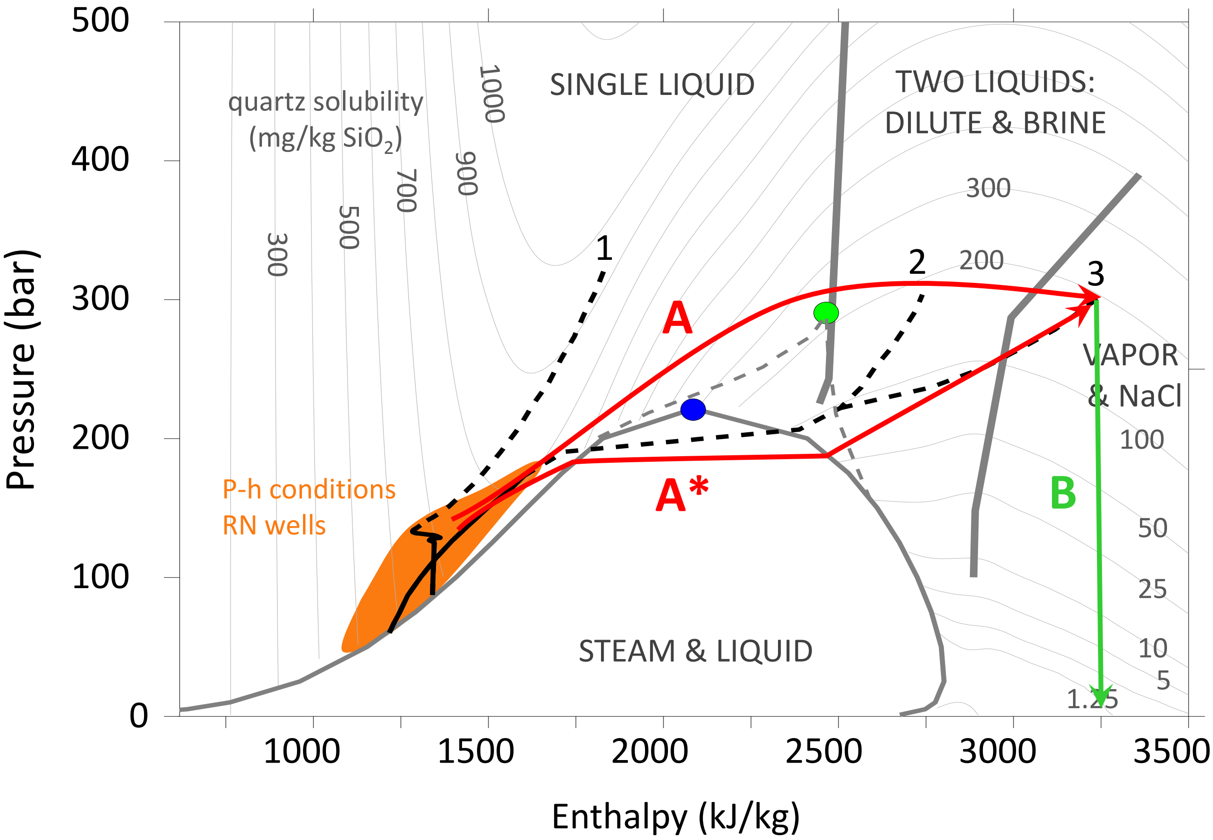

Figure 5: Phase diagram for H_2O shown in Figure 2, with added potential fluid recharge paths (A and A*) and production path (B) of scenario 3 fluid.

The production sustainability of a reservoir under scenario 3 conditions is questionable due to the large amount of dissolved solids that must precipitate along either fluid recharge pathway. In both cases some 38,000 mg of dissolved solids will precipitate from each kg of fluid. This suggests that if such a reservoir will be encountered and produced from at Reykjanes it will quickly be sealed off by solid precipitation from recharging fluids.

7. DISCUSSION

7.1 Natural analogies

The objective of the IDDP project is to reach geothermal fluids at conditions above the temperature regime of conventional high temperature geothermal fluids. Analogies to the anticipated fluid compositions in the IDDP-2 well are thus not readily available from other geothermal systems. However, observations from submarine hydrothermal vents and the IDDP-1 well in Krafla support the fluid chemistry predictions presented in sections 5 and 6, above.

The coexistence of two fluid phases predicted for temperature scenario 2 in section 5, above is supported by observations from a number of submarine hydrothermal vents. Fluids with salinities both higher and lower than seawater have repeatedly been observed (see, e.g., Coumou et al., 2009 and references therein). Submarine hydrothermal fluid salinities have been shown to vary greatly in space within individual fields (e.g. Butterfield et al., 1990; Von Damm et al., 2003). Similarly, in some submarine systems temporal variations in the fluid salinity have been reported (Von Damm et al., 1997). This is now generally accepted to indicate deep fluid separation in the roots of these submarine systems and has been supported by numerical simulations (Coumou et al., 2009). These observations give credibility to the prediction of two coexisting fluid phases under the scenario 2 temperature conditions presented in section 5.

Production of superheated steam with enthalpy of ~3250 kJ/kg (Ingason et al., 2014; Hjartarson et al., 2014) from the IDDP-1 well in Krafla similarly supports the prediction of the existence of superheated dry steam under the scenario 3 temperature conditions predicted for the IDDP-2 well. Silica concentrations as high as ~40 mg/kg were reported in the IDDP-1 steam (Ármannsson et al.,

2014) and several samples had silica concentrations in the range of 10 to 25 mg/kg. The steam samples were generally collected at pressures between 15 to 20 bar. Hauksson et al. (2014) suggest that silica concentrations in the steam may have been even as high as 100 mg/kg at full well head pressure (140 bar) and suggest that some of the silica had already condensed to dust at the sampling point in response to the pressure drop. This supports the prediction of up to 200 mg/kg of dissolved silica in the superheated steam under the scenario 3 temperature regime for IDDP-2.

7.2 Production properties

As discussed in sections 4 to 6, above, the three different temperature scenarios at 5 km depth result in drastically different predictions of the state of the fluid anticipated in the IDDP-2 well. According to scenario 1 the IDDP-2 fluid will be in most respects similar to the fluids of the currently produced Reykjanes reservoir except it will be about 80°C hotter. The high temperature will result in higher silica concentration and presumably also more voluminous sulfide scales in the well and surface equipment upon production. This fluid will most likely be manageable with conventional methods although materials for well head and surface equipment need to be selected to allow for operation at high pressure. Separation of steam and liquid at an unusually high pressure (60 bar) may also be necessary to prevent precipitation of amorphous silica in the surface equipment.

The most problematic situation arises if the IDDP-2 well encounters fluids in the scenario 2 temperature regime. The nature of the fluids anticipated under these conditions depends on the recharge path by which the fluids arrive to this part of the system. If the high pressure recharge path (A in Figure 4) is followed, two fluids; high density brine and low density dilute fluid, can be expected. If the low pressure path (A* in Figure 4) is followed, only the low density fluid is expected. Both cases will result in very challenging production properties. Production of the high density brine from the scenario 2 regime will most likely result in corrosion and scaling problems. Production of the low density fluid will on the other hand lead to partial condensation during decompression of the fluid that is expected to produce extremely low pH liquid as HCl in the steam will partition into the liquid phase. If this occurs within the well acute corrosion of the casing can be expected at and above the point of condensation. It is difficult to see how these production problems could be overcome and thus it is not likely that the IDDP-2 well could be used as a producer if it encounters fluids of the scenario 2 temperature regime.

Production of fluids from the scenario 3 temperature regime will be challenging but not impossible. The superheated steam that prevails under these conditions will contain ~200 mg/kg of silica and most likely a significant amount of HCl. The silica is expected to form amorphous silica dust upon decompression of the steam. The experience from the IDDP-1 well in Krafla shows that this can cause erosion in surface equipment, especially in orifice plates, control valves and pipeline bends (Ingason et al, 2014). The erosion problem can be minimized by maintaining high well head pressure and avoiding high steam velocities in the surface equipment. The experience from IDDP-1 has also showed that the silica dust can be removed from the steam by wet scrubbing (Hauksson et al., 2014).

Significant concentrations of HCl can be expected in scenario 3 superheated steam from the Reykjanes system. The Cl concentration in the source liquid in the system is ~19,000 mg/kg (see, e.g., Fridriksson et al., 2015) and some fraction of this Cl will volatilize as HCl in the superheated steam. The HCl concentration in the IDDP-1 superheated steam was around 90 to 100 mg/kg (Ármannsson et al., 2014; Hauksson et al., 2014) but there the source fluid is dilute, containing only 50 to 200 mg/kg of Cl. Quantitative prediction of the HCl concentration in the anticipated scenario 3 superheated steam at Reykjanes has not been made but it can be inferred that it will be much higher than in the IDDP-1 steam. It was observed in IDDP-1 that the gaseous HCl did not cause corrosion and wet scrubbing with alkaline separation water could remove and neutralize the HCl (Hauksson et al., 2014). It may be assumed that HCl could also be removed by wet scrubbing from scenario 3 steam in the IDDP-2 well but it is anticipated that caustic compounds, such as NaOH, will need to be added to the washing solution to deal with significantly higher HCl concentration in IDDP-2.

7.3 Recharge implications

The three temperature scenarios considered have different implications for inferred effects on the permeability along the recharge path of the fluid. As discussed in section 4 the thermal seawater is not expected to precipitate significant amounts of solids along the recharge path to scenario 1 temperature conditions. This is because that path is along increasing silica solubility. It can thus be inferred that if the IDDP-1 well encounters productive aquifers under scenario 1 temperature conditions the fluids can be produced from these aquifers without loss of permeability along the recharge paths.

The low pressure recharge paths for temperature scenario 2 (A* on Figure 4) and both potential recharge paths for temperature scenario 3 will result in massive precipitation of solids from the thermal seawater. This raises a concern about the sustainability of production from reservoirs under these conditions. However, the experience from IDDP-1 in Krafla has shown that superheated steam, at scenario 3 conditions, could be discharged from the well for more than 1 year in total (Ingason et al., 2014). The source liquid in Krafla is, admittedly, much more dilute than the thermal seawater assumed to recharge the depths of the Reykjanes system but this, nevertheless, indicates that reservoirs under scenario 3 conditions can support production for extended periods. It should also be kept in mind that the scenario 3 conditions in Krafla were encountered at only 2.1 km depth which may have facilitated the recharge. The longevity of scenario 2 and 3 reservoirs under production is expected to be sensitive to their volume and the hydrological connection to the more shallow parts of the geothermal system. At this stage it is premature to conclude about the viability of production from a scenario 3 geothermal reservoir at 5 km depth at Reykjanes but it seems likely that it might be hampered by solid deposition from recharging fluids and the resulting loss of permeability.

8. CONCLUSIONS

Of the three temperature scenarios expected at 5 km depth in the IDDP-2 well to be drilled in Reykjanes, the lowest temperature scenario (1) seems the most manageable from the perspective of production. The scenario 1 fluid is expected to be 380°C hot thermal seawater with similar composition as the thermal fluids currently produced from the Reykjanes field. This fluid is, however, expected to have higher silica concentration and higher potential for metal sulfide scaling than the conventional Reykjanes fluids that will call for special measures upon production.

The second most favorable scenario is that of the highest temperature (3). Under these conditions superheated steam at 550°C is expected to be produced from the well. Production of this fluid will be complicated by high concentration of silica in the steam and presumable also high HCl content. Experience from the IDDP-1 well in Krafla suggests that these challenges may be overcome by wet scrubbing of the fluid. Massive precipitation of dissolved solids along the recharge path to scenario 3 conditions raises concerns about the longevity of production from a reservoir at these conditions.

The least favorable scenario is that of the intermediate temperature (2) where either two fluids, high salinity – high density brine, and low salinity – low density fluid, may coexist or only superheated steam at about 440°C. Production of the low density – low salinity fluid and the superheated steam from these conditions will result in condensation of the fluid during decompression. The condensate will be extremely acidic as HCl in the steam will preferentially partition into the condensate. This will result in acute corrosion problem in the well. Production of the high density – high salinity brine is also anticipated to be very problematic.

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