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Initial Geochemical Monitoring Ulubelu Geothermal Field

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ABSTRACT

Ulubelu geothermal field started operating in 2012. Since then, geochemical monitoring has been conducted to see the changes that occurred in the first year of operation. Three clusters contributed to generate 2 x 55 MW: cluster B, C, and D. During the geochemical monitoring activity, a decrease in chloride and silica content occurred in Clusters C and D from the baseline until August 2012, which is associated with the cold water influx from one of the well. An indication of steam entry from shallow depth was observed in cluster B, although not quite significant but has the potency to develop a steam cap which will become benefit to extraction of steam gain. Since August 2012 until December 2013 the increasing chloride and decreasing silica trend indicated a return injection from cluster A and F as reinjection cluster. Meanwhile NCG trends in production well decreased support the conclusion about injection return.

1. INTRODUCTION

Ulubelu geothermal area is located in Tanggamus District, Lampung province, about 100 km westward capital city Bandar Lampung. (Fig. 1).

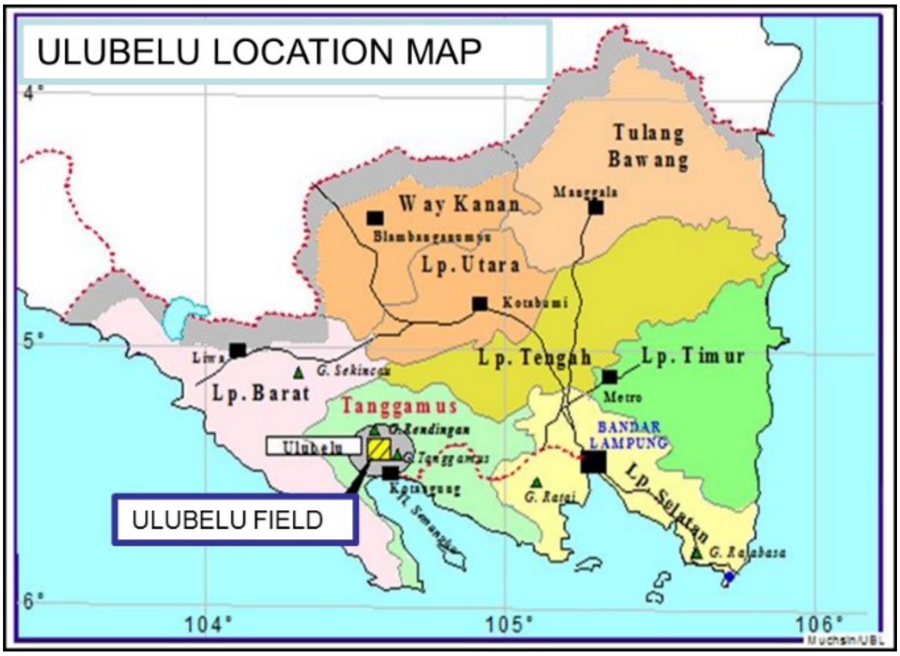

Figure 1: Location map of Ulubelu geothermal Area

Reconnaisance geoscientific studies consisting of geological and geochemical survey were carried out by Pertamina (Masdjuk, 1989) in the late 1980s. The favorable result of these studies was followed by detailed DC resistivity, gravity, ground magnetic, and self-potential surveys in 1992. Soil chemistry studies including mercury, CO_2, arsenic and acidity (pH) surveys were also conducted in 1990 and 1992. In 1993, a magnetotelluric survey was implemented to ascertain the subsurface structure of the prospect.

The promising surface exploraton studies led to the drilling of three shallow gradient wells and later three exploratory slim wells from 1995 to 1997. The success of exploration drilling lead to its development in the 2000’s. In 2012, a power plant was commisioned with a total generation capacity of 110 MW.

Based on thermal features hydrogeochemistry of Ulubelu, is flowing from Pagar Alam at the north to Way Panas at the south (Mulyanto et al, 2015). This gave a hydrogeochemistry background to estimate the water flow in subsurface.

2. GEOCHEMICAL MONITORING

A map of production and reinjection wells is shown in Figure 6.

Overall, Ulubelu uses nine to ten production wells in three clusters as follows:

- Cluster B: UBL-2, 3, 15 & 16
- Cluster C: UBL-5, 7, 8 & 27 (the latter used in the end of 2013)
- Cluster D: UBL-11 & 14

For reinjection, Ulubelu uses six wells in two clusters as follows:

- Cluster A: UBL-1, 18 & 23 (the latter used only for reinjection condensate from power plant)
- Cluster F: UBL-17, 19, & 21

The bulk of the wastewater is reinjected to Cluster A, which are generally more permeable that Cluster F..

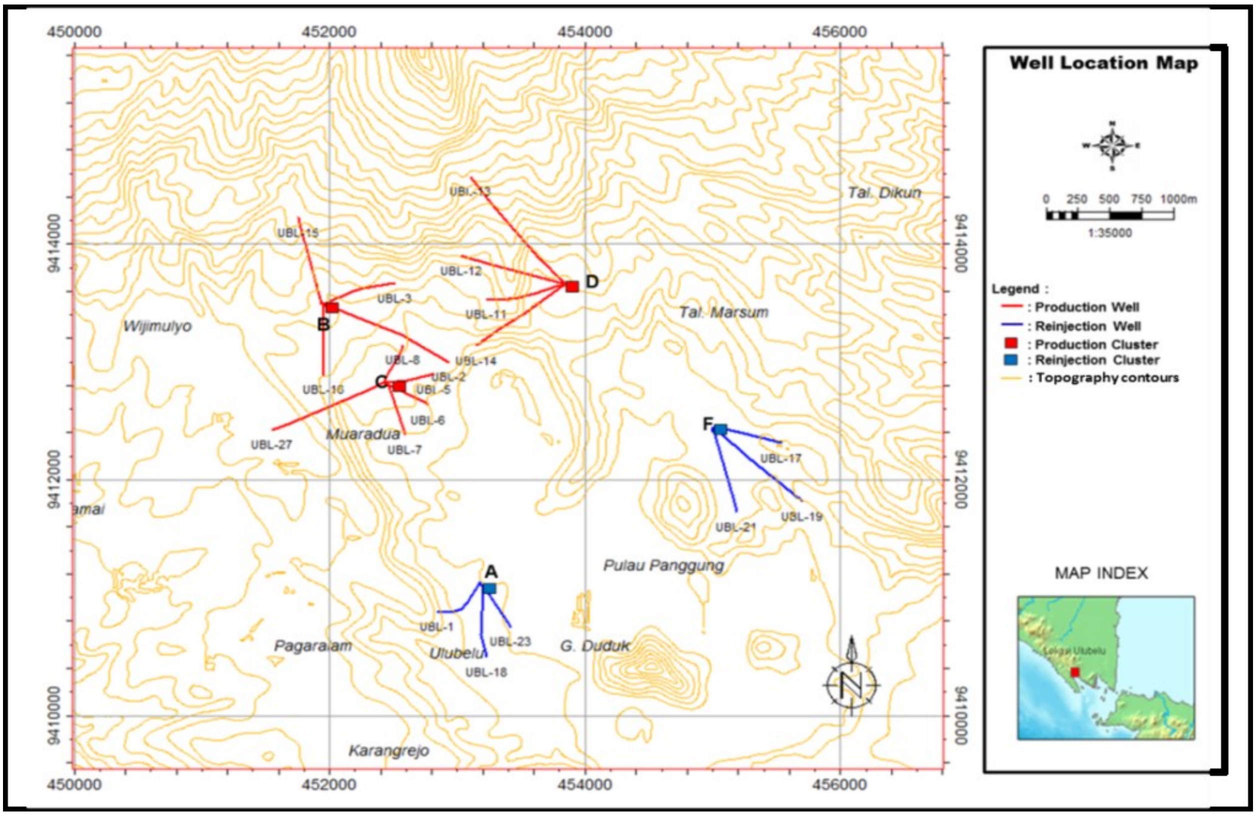

Figure 2: Ulubelu well location map

After drilling and sufficient heat up, the wells undergoes short-term (around one month) discharge tests for clearing and to determine its physical and chemical characteristics. During production, the wells are sampled monthly. In both cases, ASTM International (2014) procedures for collecting two-phase fluids are adopted with modifications to fit local conditions. Stable isotope samples were also collected but the results are still unavailable during the writing of this paper. This paper will discuss the chemistry changes observed per cluster. All concentrations were corrected to total discharge.

Wells UBL-6 (Cluster C) and UBL-12 (Cluster D) downhole surveys showed significant decline in temperatures in 2012 (before production). Downhole samples collected showed also significant change in chemistry compared to previous discharge data.These were due to an inflow from a shallow aquifer containing groundwater and/or condensate (Giriaso et al, 2013). This information will be considered in the discussions in the next sections.

2.1 Cluster B

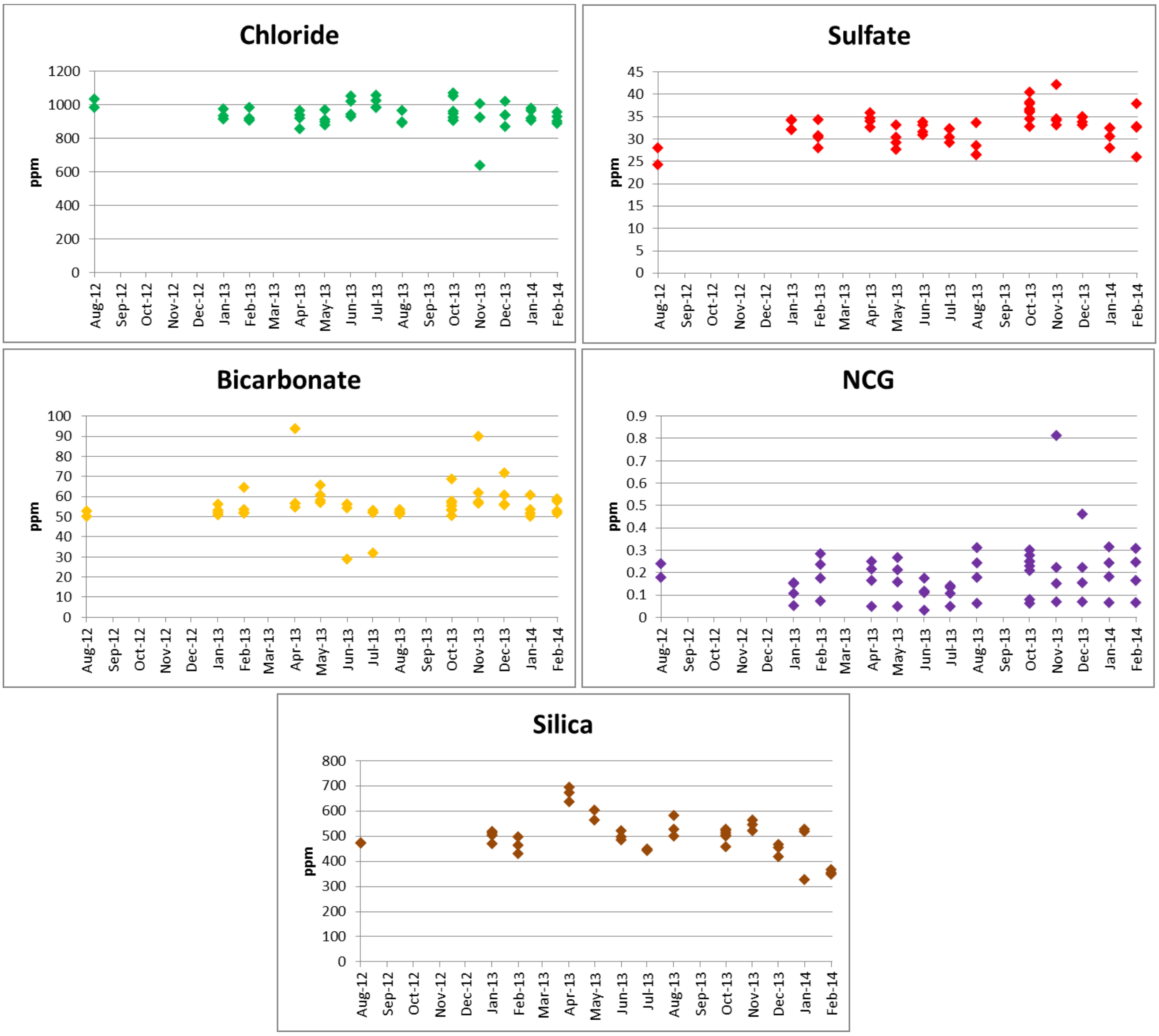

Figure 3: Chemical monitoring in Cluster B

In the Cluster B production wells, Chloride, Sulfate and Bicarbonate are relatively constant. Since the wells also show constant discharge enthalpy, together this indicates that the Cluster is least affected by reinjection returns. This may also be due to the cluster being farthest from the reinjection wells.

Silica showed a slight increase to April 2013 and decreased to the end of December. However, the decrease is similar to when monitoring started in August.

This cluster has highest NCG in the project. Their concentrations reach up to 0.3% (wt) in the total discharge.

2.2 Cluster C

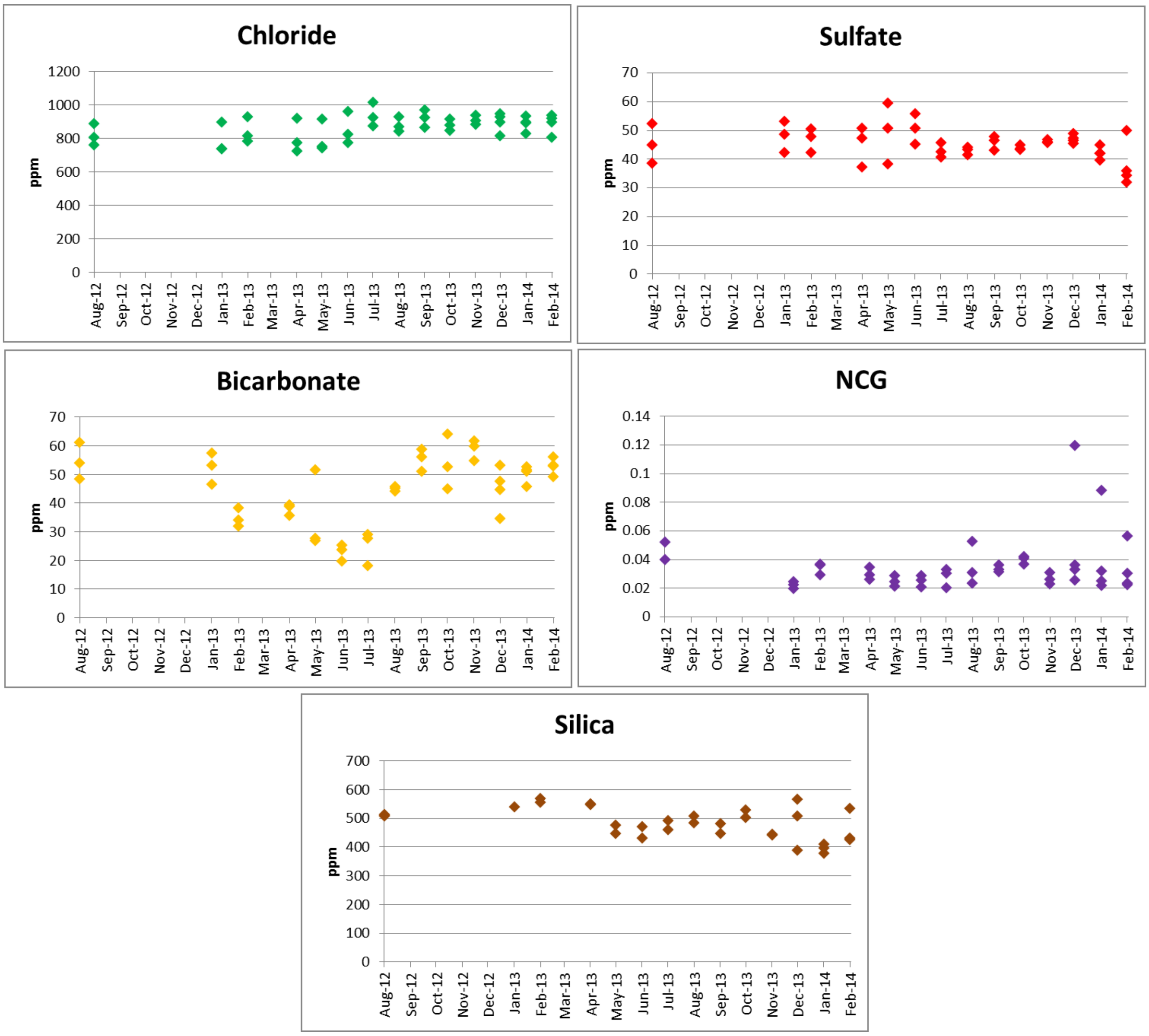

Figure 4: Chemical monitoring in Cluster C

In Cluster C production wells, Chloride and Bicarbonate show slight increase, and Silica shows slight decrease, with time. As these are near the reinjection clusters and possible connected by a NW-SE fault, a chemical breakthrough of reinjection fluids is suggested.

NCG and Sulfate are relatively constant in the cluster. As mentioned earlier, well UBL-6 in this cluster showed presence of an inflow of groundwater fluids. The results from the nearby wells in the cluster show that they are not affected by this cool inflow. However, this does not mean they will not be affected in the future.

2.3 Cluster D

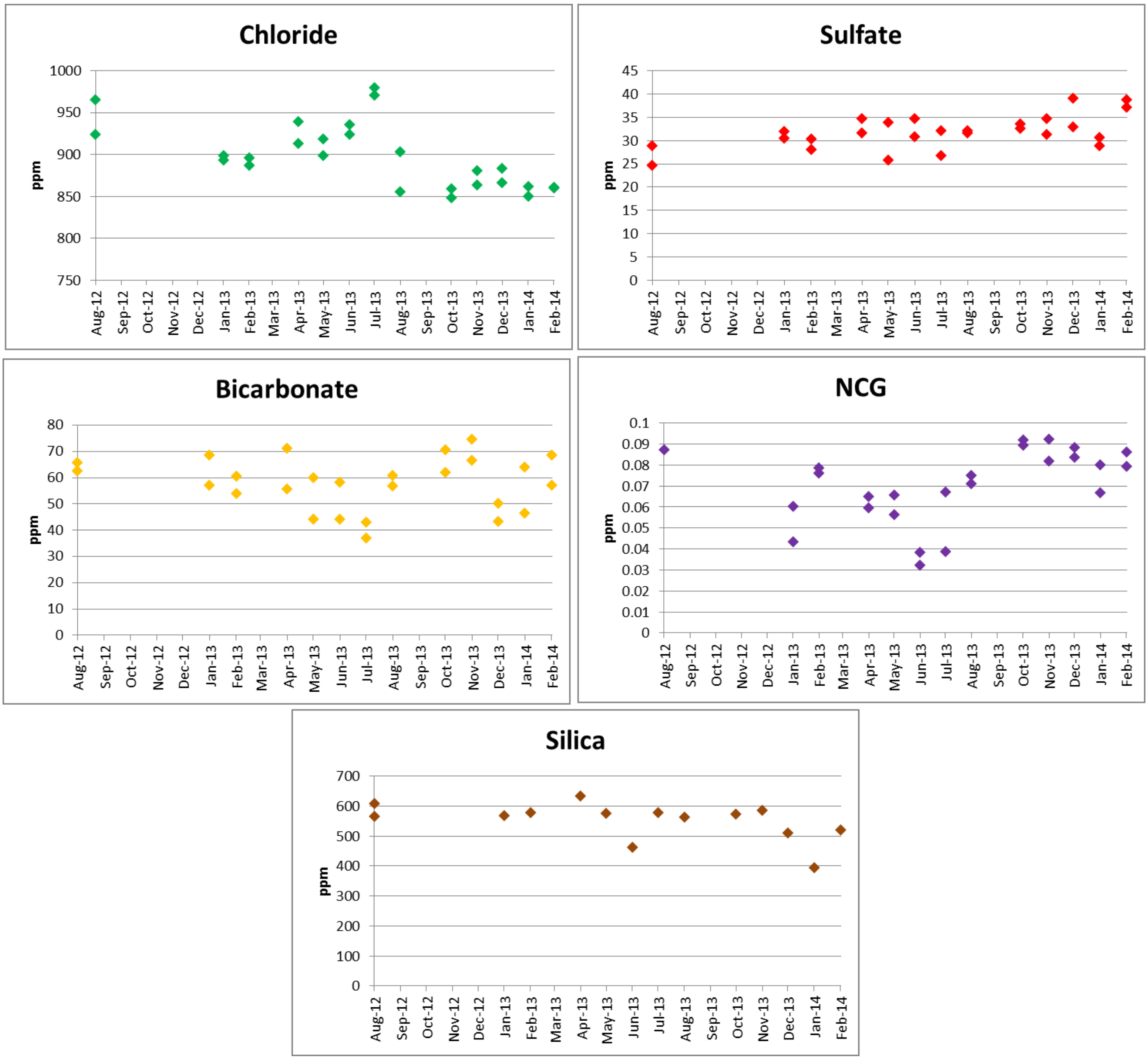

Figure 5: Chemical monitoring in Cluster D

In the Cluster D production wells, Chloride, Bicarbonate and Silica drop show a decreasing trend, while Sulfate and NCG shows an increasing trend, with time. This indicates that the wells are affected by cold water inflow from well UBL-12. This also suggests that their wells (like Cluster B) are not affected by reinjection fluids.

Giriaso et al (2014) used the program WATCH by Bjarnasson (1994) to evaluate the discharge chemistry of well UBL-11 to tee if it was affected by the cold water inflow from nearby well UBL-12. The saturation indices of silica, calcite and anhydrite was calcuated using this method. The results show a temperature drop from their mineral saturation.

2.4 Field Trends

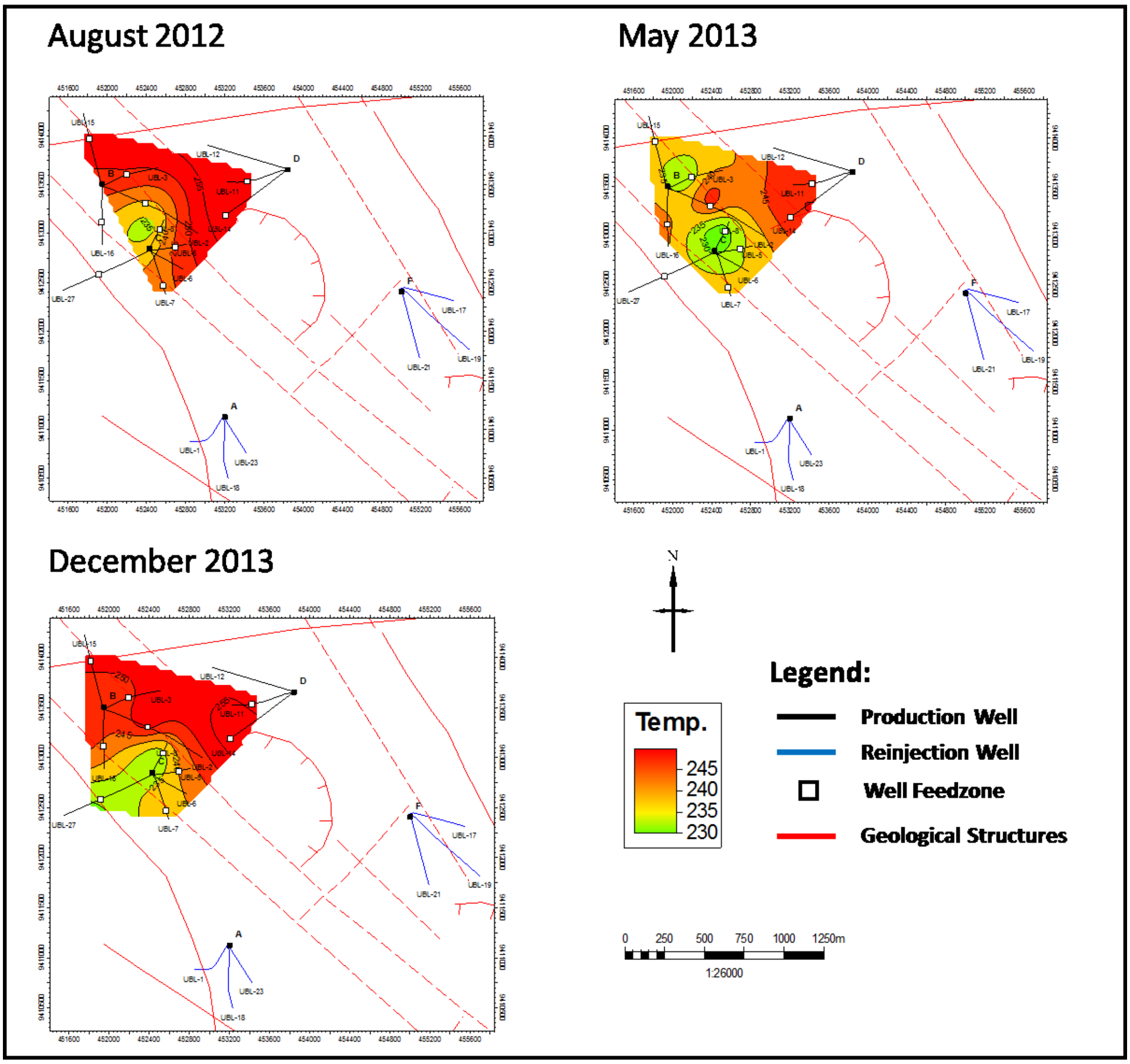

Figure 6: Ulubelu isotemperature (^{o}C) contours based on Truesdell (1976) quartz adiabatic cooling geothermometer

Truesdell's (1976) quartz geothermometer, asssuming adiabatic cooling, was calculated in the the wells and plotted at the main feed zone to make an isotemperature conours across the field (Fig. 8). Highest temperatures are found in the northern and easter sectors are found in August 2012 when production started. However, in May 2013, these was confined only to the eastern sector. This suggests that the production wells are affected by the cold water inflow found in well UBL-6. However, by December 2013, the northern sector temperatures increased to August 2012 values. To prevent further cold water inflow, it is proposed that workover be conducted in well UBL-6.

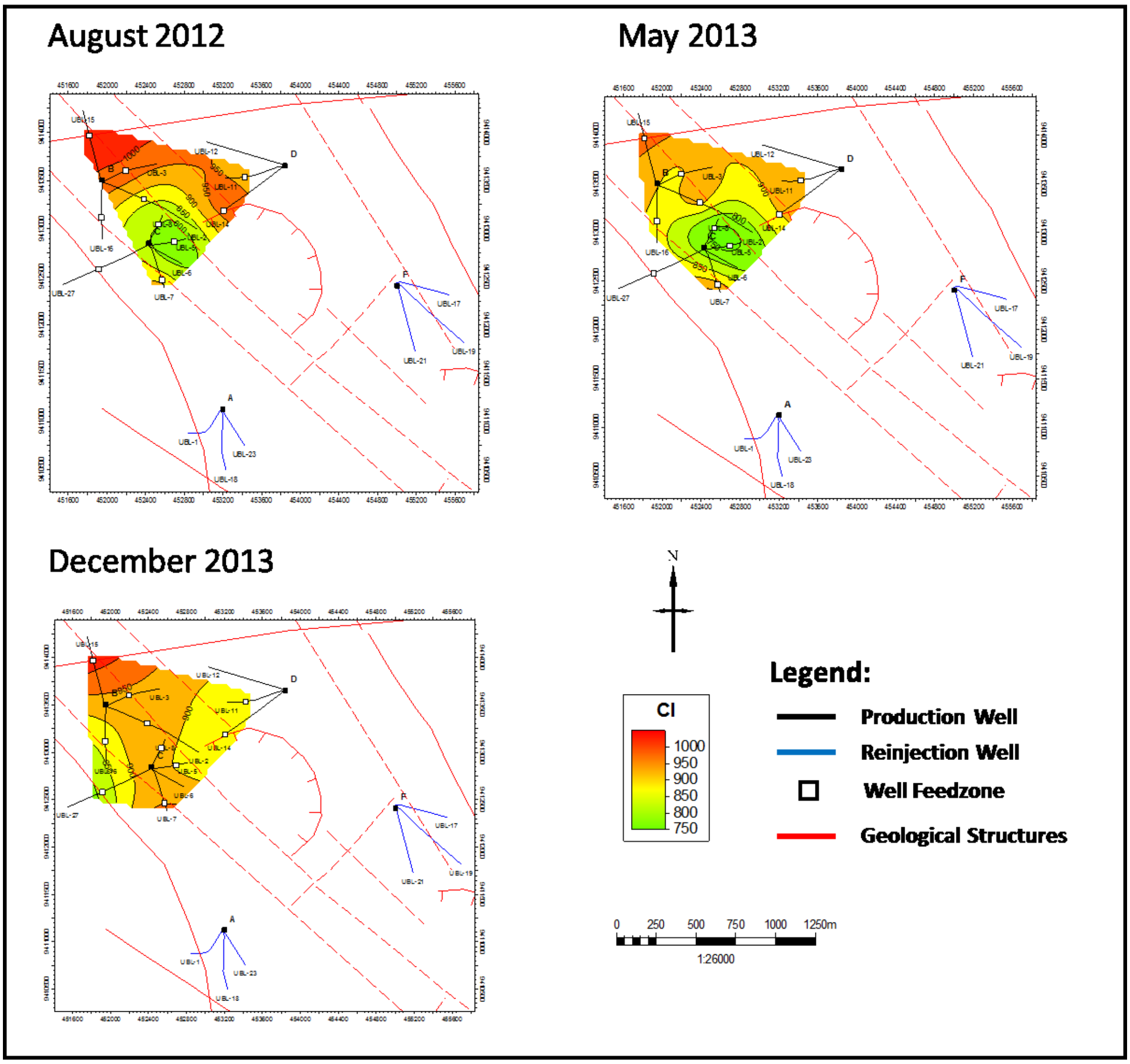

Figure 9: Ulubelu iso-Cl total discharge contours

The total discharge isochloride contours are plotted in Figure 9. Lower Chloride entry in the south up to May 2013. However, in December 2013, this effect was not seen. This can be explained by the addition of well UBL-27 in cluster C in during the period. Another is due to the entry of reinjection fluids to the production sector from the south. The lower Chloride found in May 2013 which increased by December suggest influx of reinjection returns.

Tracer tests and microseismic earthquake (MEQ) survey are programmed in 2014. These will provide additional information and give a clearer picture on the effect of reinjection returns.

3. CONCLUSIONS AND RECOMMENDATIONS

Cluster B has highest NCG content than the others, The chemistry also suggests that it is the least affected by reinjection returns, although silica concentrations were found to decrease slightly.

Injection returns are notably observed in cluster C. This is likely because they are the nearest to the Cluster A reinjection wells where main bulk of wastewater are disposed. Also there is a NW-SE geological structure that connect these two Clusters. Also, cold water inflow in well UBL-6 affected the performance of the other wells in the Cluster.

Cluster D also has a well (UBL-12) with cold water inflow. Mineral saturation calculations show a temperature drop in nearby well UBL-12 because of this.

Isotemperature contours, using quartz geothermometry, indicate higher temperatures in the north and lower temperatures in the south. Isochloride contours also show a similar trend with higher concentrations are also found in the north. Lower temperatures and higher chloride concentrations in the south indicate reinjection returns.

A tracer test conducted in 2014 and availability of the stable isotope results should provide a clearer picture of the reinjection returns and the hydrochemistry of the area.

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