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Exploration Dirlling on the TPGP Tangkuban Parahu Concession, West Java, Indonesia

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ABSTRACT

This paper reports the results of initial exploration drilling of a 44,000 km2 geothermal concession associated with the large Tangkuban Parahu stratovolcano in Central West Java, Indonesia. The concession was awarded in November of 2009, to Tankuban Parahu Geothermal Power (TPGP). A geothermal reservoir with the potential to support two 55MW power plants could be associated with the broad Sunda – Tangkuban Parahu "TBP" volcano. TBP has a summit height of 2066m asl.

The young volcanic craters on TBP have experienced phreatic eruptions cyclically for about three weeks every 2 – 3 years since 1926. In November 2011 the summit crater experienced the input of magmatic gasses and fumarole temperatures of 286°C were measured.

Acidic hot springs occur both on the north and south flanks of TBP, less than 5 km from the summit crater. Neutral pH warm springs are found within 9 km S, SW, and N of the summit.

Reconnaissance of the TBP field was initiated in 1970 by Pertamina. In 2010-2011, the Energy and Geoscience Institute "EGI"-USA, working under a USTDA grant awarded to PT Indonesia Power, conducted additional fluid geochemical sampling, a noble gas sampling survey, and an extensive magneto-telluric (MT) survey covering ± 80 sq. km. Analyses suggest a high temperature liquid-dominated reservoir. Faults which may provide conduits for hydrothermal fluid transmission, were identified using various satellite imagery, aerial photography and a recent LiDAR survey. The interpretation of the MT survey suggests the main up flow zone occurs beneath the youthful main volcanic edifice, with hydrothermal outflow extending in several different directions for varying distances. The potential is not yet known, but reservoir temperatures of 250oC to 300oC are suggested by geothermometry calculations.

The Kancah area, on the south flank of TBP, was identified as the priority location for drilling of the first planned 3 slim holes. These will be rotary drilled to about 630 m, then core drilled to target depths of about 1500 m TD.

Data from the exploratory core holes will be used to target full-sized production test wells. The MT survey suggests the target depth for the reservoir zone may be 2500 – 3000 meters

Results of the slim hole drilling, planned for 2014, is reported in this paper. TPGP is working with the local government and agencies in a time-consuming process to obtain required permits. These include permits for land clearing, environmental monitoring and management, and temporary retain and disposal permits for drilling fluids and cuttings. Among other challenging efforts, the company is not only working with local officials to facilitate permitting but also to afford employment opportunity for local unskilled labors and conduct community outreach about the project.

1. INTRODUCTION

The depth temperature gradient drilling and combination of rotary drilling and coring is planned for the first 3 exploration wells in Tangkuban Parahu "TBP" area of concession. In some geothermal area where drilling targeting is well defined then the core drilling has not been very common in the past, therefore in more challenging fields, the uncertainties in siting the initial wells are greater, then to reduce cost and risk on exploration deep slim hole drilling become increasingly option to be used in geothermal exploration and delineation. Inclined slim holes can now be drilled deeper with smaller rigs and with improved well control to test the geothermal reservoir

In TBP area, a deep core drilling project is prioritize to focus on south bench of the volcano, while further evaluation on north concession is awaiting after accomplishing exploration and production in the south area. Slim-holes with continuous coring from 620 m depth up to 1500 m depth to target based on geology, geochemistry analyses and low permeability formation as shown by 86 MT stations survey.

The first 3 locations of exploration drilling is to test the possible geothermal system driven by apparent fault line clearly seen from aerial photo sensing and LIDAR survey. To name the first 3 slim holes and coring is K – 1, K – 2 that located in forestry area, while K – 3 locate in green tea plantation area. Beside geothermal secondary mineral taken from continuous core sample, it is also very important to measure the down-hole temperature in the area, after the fluid in the well is in equilibrium with the temperature of the formation.

2. TBP CONCESSION AREA AND PRIORITY AREAS FOR DEVELOPMENT

On the 44,000 ha area of TBP concession, it is suggested that there are essentially three independent areas commendable for continued exploration, in view of timely priority of exploration. These are as shown in figure – 1, P1 - the Kancah area on the south flank of the volcano where hot springs and ground collapse presented in the area are. P2 - the Batu Gede/Ciracas area to the north of TBP where hot spring with neutral pH and bicarbonate leaks on the surface. And P3 - the Situ Lembang Valley on the west side of the volcano, that indicate a brittle mafic rock in between old TBP and much younger TBP crater.

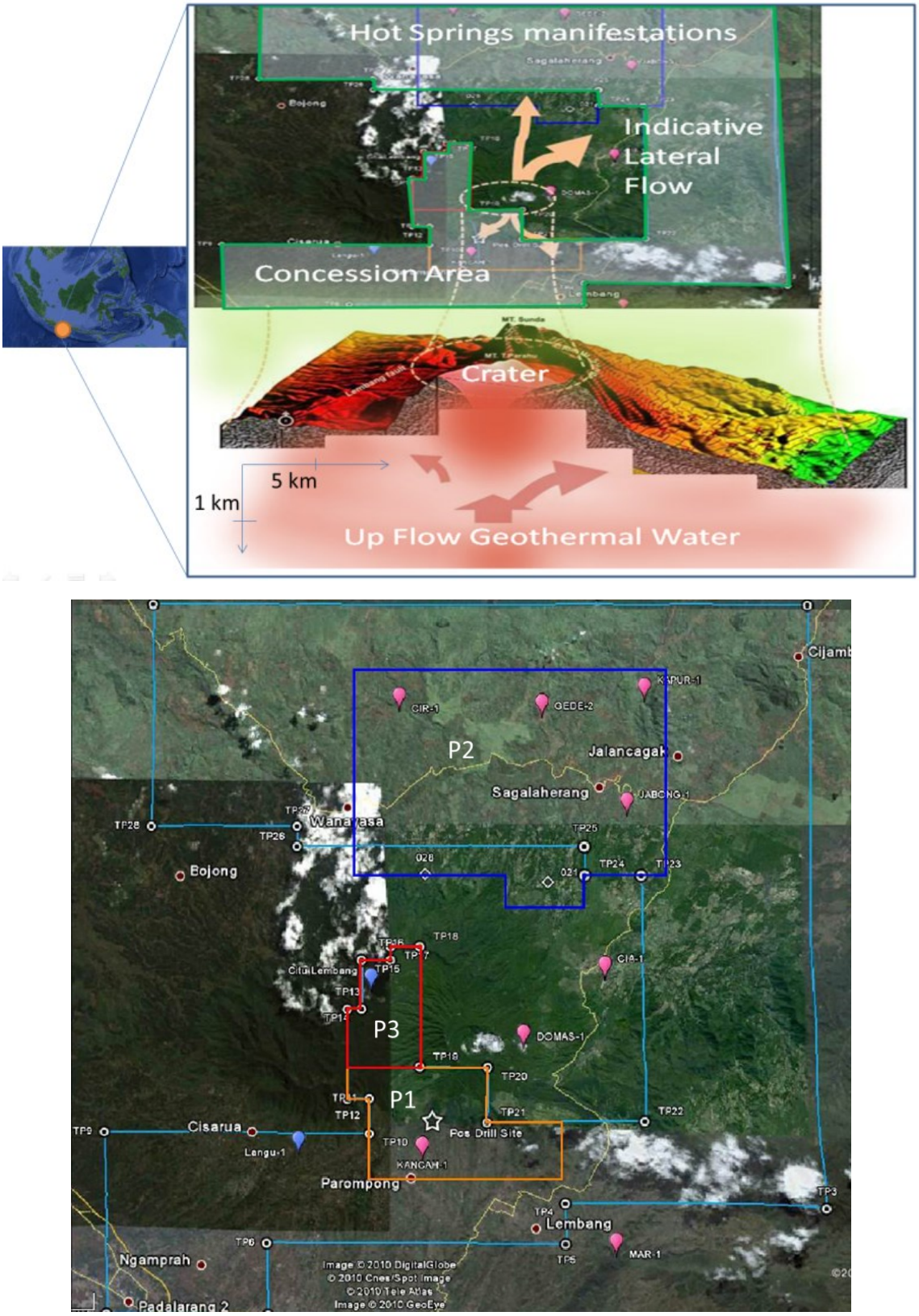

Figure 1; Distribution of TBP hot spring manifestations and priority area for developments.

3. DEEP TEMPERATURE GRADIENT DRILLING AND CORING

The first spud in exploration drilling for K – 3 was begin on April 22 and planning about 35 days to complete the drilling and coring, and extra 3 days planned for down hole temperature measurement and possibly water sampling from the well. K-1 supposed to be the first drilled exploration well, therefore due to the prolonging to get permit and land clearing on forestry area where the seated K-1, then turn to K-3 seated on tea plantation that all permits and land clearing has been accomplished.

The seated K-3 is to test the reservoir hot fluid leakage along fault that clearly seen on south-west to north-east orientation. In the end of north - east fault line, it is interpreted to control the high flow rate of geothermal spring that known famously for spa and geo-recreation center in Ciater. The available relevance data either from geochemistry and geophysics data are very limited data. Survey geochemistry along the fault line found leaking acidic ground water, low temperature, yellowish color, that interpreted as ground water inferred with magmatic gases such as sulfur gas. The available core log will presents the advantage of observing reservoir lithology, hydrothermal mineralogy and fluid inclusion, fracture character as well as. The rock properties saved on core log also useful for future reservoir engineering data.

In view of exploration risk and cost incurred, the slim-hole and core drilling cost is known to be lower than production drilling, due to the lower size of rig used and smaller area released for pad, access road and others infrastructure required. The target of drilling K-3 is to get as much possible subsurface geothermal data, to include at least geothermal alteration mineral and high temperature down hole, before to decide drilling on deeper production wells. MT survey suggests the TBP reservoir is underneath of low resistivity formation at depth 1500 – 2000 m below sea level or about 2500 – 3000 m below ground surface. The target of TD coring of 1500 depth to expect the up flow reservoir water through the south – west to north – east targeted fault line, and lateral flow through fracture on lava flow and been detected in the core log of the K – 3, exploration well. Hot fluid flow channeling along fracture orientation will silicified in the rock, and to alter the host rock to become geothermal mineral such as hematite, adularia and epidotic.

4. DRILLING PROGRAM AND DRILLING RIG SPECIFICATIONS.

As drilling targeted fault on K-1, K-2, and K-3 as shown in figure 3, it is predicted that the intersection of the tree apparent fault line is an up flow reservoir water, and further lateral flow down to south due to gravity. The drilling program is set out to have an optimum cost effective but still have well safety concern during drilling execution. Drilling program for K-3, is as the following;

- Set stove pipe about 5 meter for drilling bit diameter of 13 3/8 inch.
- To drill with 13 3/8 inch hole down to 120 m, and avoid falling formation by installing 9 inch casing and is cemented.
- To further drill with 8 ½ inch drill bit in diameter, down to 350 m and set up 7 inch casing and is cemented.
- To further drill with 6 ¼ inch drill bit, down to 620 m and set up 4 ½ inch casing and is cemented.
- To do continuous coring HQ 3 7/8 inch from 620 m to TD 1500 m.
- To lay down in the hole 2 7/8 inch tubing, and allow the fluid well and formation to equilibrate before to do periodic down hole temperature measurement in 24 hrs, 48 hrs, 72 hrs. To take a fluid sample is possible and do geo-thermometer analyses from down hole sampling fluid.

The one alternative suitable drilling rig is truck mounted hydraulic rig that have capability to do rotary drilling and coring as well. The lifting rig horse power is 800 KN that capable to run 7 inch casing at 350 m long.

	Hydraulic Drilling Rig Specification MCQ 700		
1	Automobile Chasis	Type	WS5545H
2		Driving Pattern	10X6
3		Driving Power	276 KW
4	Unit head of truck mounted CBM drill rig	Torque/ Rotary speed	20 kNm/ 85 RPM
			10 kNm/85 RPM
		Inclination Angle	0-85°
		Travel	15 m
		Trhu Holew Diameter	75 mm
5	Feeding System	Hoisting Capasity/Speed	800 Kn- 22 m/min
		Pull down Cap./ Speed	160 Kn - 55 m/min
6	Drilling Capacity (for Reference)	Dia. Drilling Rod/Drilling depth	Φ89mm/3200m
			Φ114m/2200m
			Φ127mm/1600m
		Rotary Diameter	Φ800mm
7		Lifting Force	40Kn
8	Diesel Engine	Model	KTA19-P700
		Power/Rotary Speed	522Kw/1800rpm
9	Hydraulic System	Form	Open
		Output Volume	2×130+2×100+2×60(L)
		Pressure	Pressure 32Mpa
10	Working Height	Highest	22m
		Lowest	13.8m

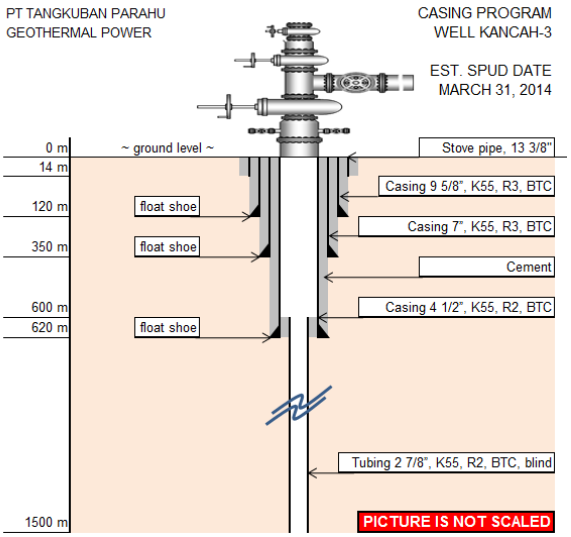

Figure 2; Drill rig specifications and drilling program for K-3.

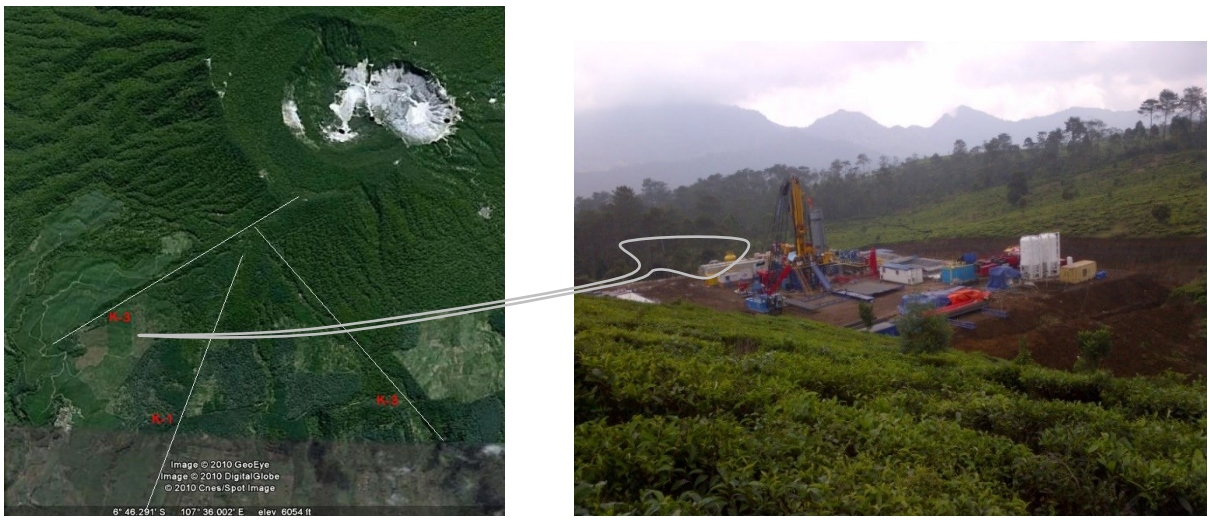

Figure 3; The 3 apparent fault line targeting for K-1, K-2 and K-3 exploration drilling wells.

5. KANCAH – 3 DRILLING HISTORY.

The Kancah – 3 hole was spudded on April 22, 2014, no return when drilled with 13 3/8 inch bit down to 18 m. From ROP of the drilling bit eventually formation interpretation as pyroclastic tuff with medium hardness. To kill the formation lost put into the hole fine wood saw material as loss circulation material. To plug the formation loss, the hole is full cemented. When further drilling on cemented hole, no return encounter at depth of 14 m, noticed small cracks outs ½ inch outside the cellar and the drilling fluid coming out to the surface out of the cellar. Continue blind drilling with water drilling fluid and controlling the ROP and when reach the depth of 18.8 m noticed 5 spots drilling mud come out the surface outside of the drilling cellar crack on the ground. For safety reason from potentially collapse of the structure of the rig due to wash out underneath, the drilling was stop.

To overcome the 5 (five) spot ground crack outer of the cellar and further possible collapse of the drilling structure and cellar structure, then the decision was taken to enlarge the original drill hole of 13 3/8 inch with larger drill hole of 17 ½ inch. Then set up casing 13 3/8 inch and kill the leak formation with cementing casing as soon as the drill bit encounter hard formation. In order to drill 17 ½ inch drill bit, the stove pipe of 13 3/8 shall be taken out. Re-drill the hole with with 17 ½ inch bit on the same hole. When the drill bit down to 25 m depth the ROP of the bid was down and the drill cutting return to the surface presented rock formation of andesite basaltic rock. This is hard formation and suitable to set up 13 3/8 inch casing, therefore to get full casing seat on above hard lava flow formation, continuous drilling up to 30 meter, then reaming from 25 – 30 m hole. Then pull out the BHA lay down and set up casing shoe run down at 25 m, run in hole casing 13 3/8 inch and cementing. Awaiting about 12 hours is to have the cement slurry become hard enough for further drilling.

To continue drilling with bit 12 ¼ inch, to target depth of 120 m, then lay in hole 9 inch casing. Therefore when drill bit down to 64 m depth, no drilling cutting return to the surface, drill pipe become stuck, after back off and reaming with 40 ton torque the stuck pipe was released and continue drilling with water since there is no return of drill cutting up to 114 m depth. Pull out the drill bit and reaming, pull out and lay down BHA for cementing preparation of 9 inch casing.

When put the cement slurry to the hole with excess of 100% through annulus, there is no cement return to the surface. Awaiting for 12 hour to have cementing to bond and dry, then put the second cement slurry from the top with 100% excess, still no cement return to the surface, the third top job cementing have the same result that no cement return to the surface. Then after cut the casing on the ground level put LCM plastic rope manually from the surface through annulus in order that the LCM will stop down in the centralizer, then put the viscous cement from the surface manually up to the hole is completely full of cement.

Before further drilling to target of 320 m depth with 8 ½ inch in diameter, set up BOP 13 3/8 inch for safety reason and is compliance with drilling procedure safety precaution to avoid possible blow out from the deeper formation. When drill bit reached about 300 m depth, the ROP is very high and the drilling cutting is mud and further interpretation is the old caldera lake deposit of the mountain before the new TBP formed. Stop drilling at 338 m and set up 7 inch casing. This is the only drilling path that have full return on drilling cutting and only need about 2 days to accomplished drilling, set up casing and cementing.

In order to further continue drilling program to drill target at 620 m depth, to change BOP size from 13 3/8 inch with smaller BOP of 7 1/16 inch. To continue drilling with 6 1/8 inch bit, from 338 m to 620 m target, therefore when drill bit down to 614 m depth no return of mud and drill cutting. Lessen learn from previous blind drilling from 60 m – 111 m depth when no mud return to the surface, that finally very difficult to plug the formation with cement slurry on the leakage formation (1 time cementing from the bottom, and 3 times top job cementing) then when noticed 100% no return of the mud drilling fluid then pull out the BHA lay down and prepare to plug the loss formation. When pulled out the bid and lay down completed two joint, then the oil seal of the top drive burst and pipe can no longer rotate to pull out the string, then finally the drill string become stuck at depth of 593 m depth. Pumped pipe lax chemical 5 bbl and wait for 8 hour before start to try to pull out the bid, therefore the bid was no move and then pumped black magic chemical 30 bbl to the hole and wait up to 8 hour. Then pull out the bid and rotate from 591 meter to 391 meter and spot again black magic 5 bbl, and continue to lift up BHA from 391 to 333 m depth, but the drill pipe is broken, and fall off the hole. The fish in the hole consist of DP 3 1/3 inch 10 joints, DC 4 ¾ inch 10 joint, drilling jar, stub, bit sub and bit 6 1/8 inch. To fish use jar and ready to run die collar. When running the drilling jar to fish, after 167 running of the jar, then malfunction of the top drive, and drilling was stop. The decision was made to change with the new drilling rig due to safety concern for the crew.

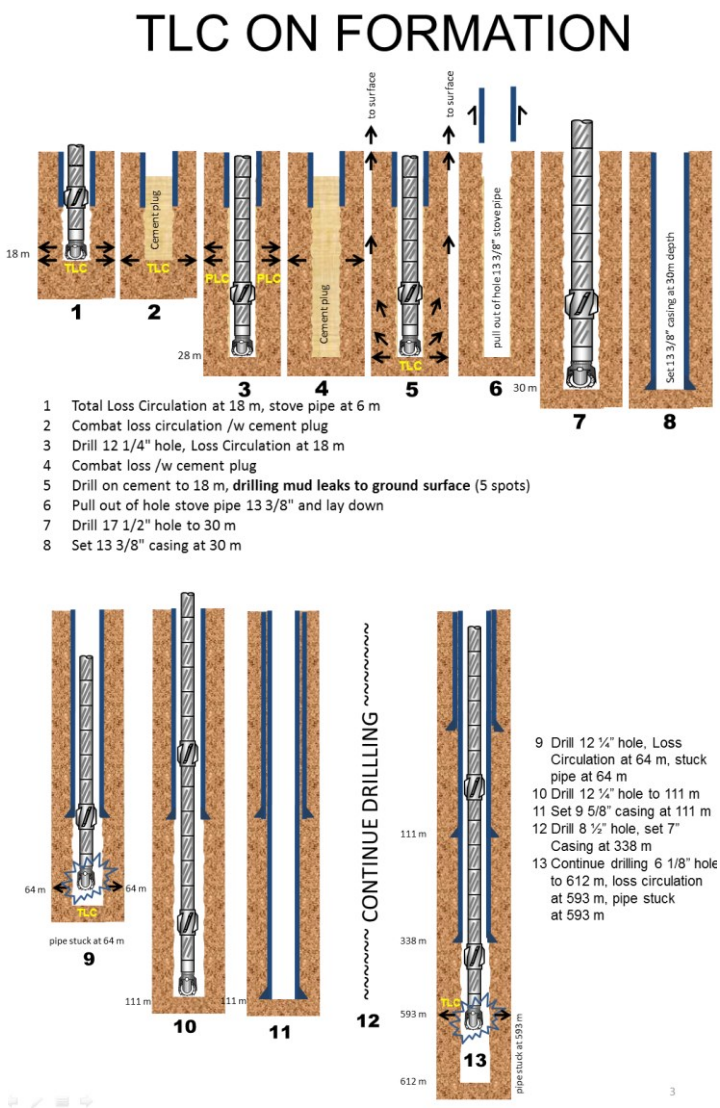

Figure 4; Recorded TLC at 18m, 28 m, 64 m, and 593 m. Drill string was broken at 333 m, and fish about 200 m long.

In order to release the pipe stuck on formation, it used drilling jar for 2 days. The fish has moved up about 6 joint and need more a couple of joint before all the fish is above the 7" 320 m depth casing shoe, before finally pull out by the drill pipe. Unfortunately at 23:35 hours on 20 May 2014, malfunction of the top drive rendered to the drill rig in operation for safety consideration. The malfunction potentially could have caused further damage to other equipment's and presented safety hazard to rig personal.

The decision is made the change the drilling rig, that best estimated need a time for 45 days. During awaiting of new drill rig, the fish and drill pipe assembly is hung on the well above the casing head and above the BOP to make sure that potential fall down can be minimized.

6. CONTINUED DRILLING WITH NEW DRILLING RIG.

As of May 22, 2014 the exploration drilling for K-3 is stop, after the malfunction of the top drive and having concern further potential cause damage on equipment's presented a safety hazard to the rig personal.

It is estimated that time delivery for new rig is about 1 – 1.5 month. Then continue to lift up the fish and continue drilling from 611 m – 700 m (depending on the hard formation for casing seating), then continue with coring up to 1500 m TD.

We are expecting that this report could include the well bore temperature survey on K-3 and assessment notices on secondary mineralization on core log.

7. KANCAH – 3 DRIL CUTTING LITHOLOGY.

Summary of noted formations and important drill cuttings from K-3 are as following;

- During drilling the K -3, no drilling fluid return at 0 – 28 m, 54 – 98 m, and 612 m, interpreted the bit intercept high permeability formation.
- 28.3 ANDESITE TUFF: Medium gray with 15% moderate reddish brown and moderate reddish orange; moderately hard; aphanite to micro-porphyritic with common coriaceous fragments; groundmass of quartz and plagioclase; micro-

phenocrysts of pyroxene; sample heavily contaminated with cement and soil; no hydrothermal alteration noted; minor hematite and limonite weathering/alteration noted on coriaceous fragments.

- 298m-352m; Just before 300 m went into a soft grey lacustrine mudstone. Very soft when exposed to water, a little more competent when dried. Some of it contains silt-sized crystals and lith frags that are very angular and show no signs of rounding. Most of it is just mud. No sign of secondary alteration. Occasional small wood (charcoal) fragment. No CaCO3. May be volcanic Crater Lake deposit.
- 600m-612m: The samples are very fine grained. The reason for this is questionable. There were problems with both the shaker table and circulation in the hole. The samples are mainly crystals and small fragments of vitrophyr All fresh and hard. @ 600m xls>vitro, @606m = equal, @ 612m vitro>xls. These samples have far less magnetite than above. Sample at 612m = last before getting stuck.

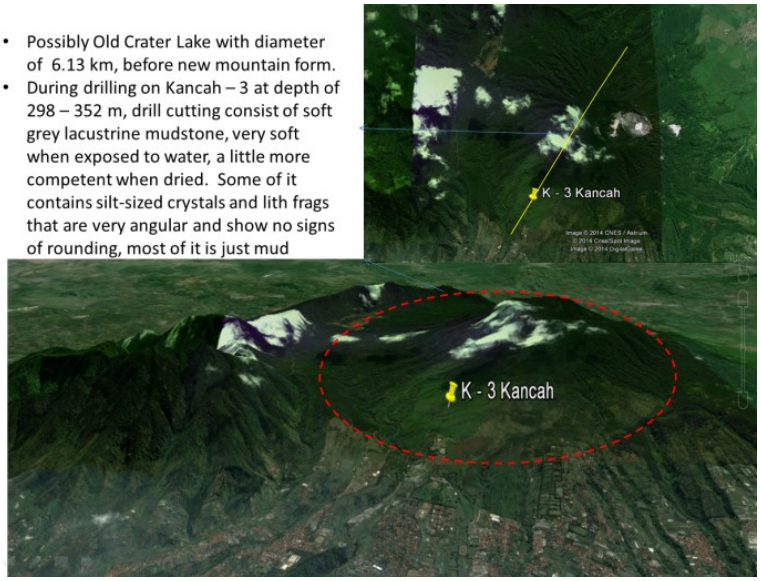

Figure 5; recorded no drilling fluid return at depth and K-3 seated on old caldera crater before TBP ids formed.

8. CONCLUSION

Based on the above explanation, we can conclude as following:

- K-3 slim hole exploration drilling is a step ahead of geothermal surface study to measure temperature gradient at depth of 1500 m and to seek secondary mineral associated with geothermal system underneath TBP volcano. Production drilling strategy to include estimated well capacity, delineation boundary of the reservoir up to design the number of selected pads location to support the presume power plant capacity of 2 x 55 MW power generation plants are depending on the quality of K-1, K-2, and K-3 of which K-3 is the first exploration well drilled.
- Permeable formations presented by intercepting total loss circulation (no drilling fluid return) at depth of 0 - 28 m, 54 - 98 m, and 612 m during drilling K-3 should have been concerned before starting to drill the second K-1 and third exploration drilling K-3, to mitigate as best possible pipe stuck due to accumulation of drilling cutting above the bit that not been recovered by high viscosity drilling fluid. Preparation of LCM and suitable cementing ingredients are crucial to success the drilling of K-1 and K-2.
- Preparation of drilling rig included modus spec assessment, selection of drill bit material in response of the hardness of formations are also important in view to accelerate accomplishment the drilling K-1 and K-2 by reduce tripping and down time of the drilling rig.
- The well bore temperature gradient in K-3, and the secondary mineral associated with fluid rock interaction will be presented when the data is available.

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