IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 7, Issue 3 Ser. I (May. – June. 2019), PP 25-28
www.iosrjournals.org

Geological Conceptual Model of Olkaria Geothermal System

Monicah Kimonda Kibet[1, 3*], Paul K. Sang Magut[2], Jacques Varet[3]
[1]*Kenya Electricity Generating PublicLimited, Kenya*
[2]*Department of Chemistry, Dedan Kimathi University of Technology, Kenya*
[3]*Geothermal Training and Research Institute, Dedan Kimathi University of Technology, Kenya*
Corresponding Author: Monicah Kimonda Kibet

Abstract: *Conceptual model of geothermal system is focused on geological and geophysical information, temperature and pressure data and geochemical content of reservoir fluids. The conceptual model explain the heat sources for the reservoir, the location of recharge zone as well as the main flow channels and patterns within reservoir. Geological conceptual models are mainly based on analysis of geological data. The method used to develop geological 3D model in this study, geological data was obtained with the permission of KenGen management, the data is imported into datasheet in rockworks software, and in borehole manager lithology model was chosen. Then lithology model appear on the screen, export the model to paints for editing and modifying other features like structures, the heat source, up-flow and in-flow and finally recharge zones based on lithology, alteration mineralogy and temperature models. The Geological 3D conceptual model shows that trachyte formation forms the reservoir rock of Olkaria geothermal systems. The cap-rocks that overlie reservoirs rocks are the basalts and tuffs and presence of intrusions in the well OW 924A indicates the heat source is near to the geothermal system and finally structures acts as the recharge and the discharge zones.*
Temperature models in the study area show that the wells around OW 923A and OW 39A have higher temperatures indicators of the up flow zones. The intrusions at OW 924A indicates that the heat source is near the systems. The Geological structures act as conduits of recharge and discharge of fluid flow in geothermal system in the study area.

Date of Submission: 22-06-2019 Date of acceptance: 10-07-2019

I. Introduction

Based on available geological, geophysical information, temperature and pressure data conceptual model of greater Olkaria system have been revised by several authors (Axelsson, Arnaldsson, et al., 2013). The first conceptual model was developed by(Swesco & Virkir, 1976) based on the existing data at the time. The model was simple since insufficient data from drilled wells was available at the time. Sweco and Virkir suggested a boiling geothermal reservoir enclosed by steam zone controlled on the top by tuffeceous cap rock. Field optimization studies to update the conceptual model indicate that the heat sources is seated deep in the magma chamber with the intrusions 6-8 km(Mannvit et al., 2011) At 850 m basalt act as the cap rock while the trachyte rock is the reservoir and it starts from a depth of 1500 m. the heat source is near the geothermal systems because of existence of intrusion of some wells(Kibet et al., 2019)

The greater Olkaria Volcanic complex has fast networks of faults that were formed during dissimilar tectonic episodes. NW –SE and WNW – ESE are believed to be the oldest faults which are related to the formation of Kenyan rift systems (Mungania, 1999). NE-SW are much younger and are related to the caldera collapse (Omenda, 1998). Along the Ol Njorowa Gorge Dykes have been exposed trending N-S. These dykes are associated to the N-S and NNE – SSW faulting creating numerous fumaroles and craters laterally the Ololbutot fault and the gorge (Musonye, 2015). The young dykes form significant heat sources as well as good permeability. When dykes are crisscrossed at deeper depth through drilling, they improve steam production. For example during the drilling of well OW 921A a dyke was intersected at the depth 2,126 m (KenGen, 2014).This may have enhanced the productivity of the well making it one of the biggest producers in Africa.

Four main up flow zones were identified during the optimization, the first major up flow feeds the Olkaria west field thought to be linked with the heat sources below Olkaria hills. Two major up - flow zones were identified as being connected to the Gorge farm heat sources. The fourth up flow zone is related with the ring structure in the domes field, associated to the heat sources identified below that area (Rop, 2013).

In 2002 Ofwona amended the model and proposed two up-flow zones, one in the Olkaria Northeast and another in the Olkaria East field (Figure 1) the recharge side from his model indicated it was from all sides of Olkaria. Ofwona (2002) also indicated that the Olkaria West field was not connected to the Olkaria East field but was separated by a low- temperature zone in central Olkaria. Extensive boiling also occurred in the up-flow zones to form steam caps below the cap-rock.

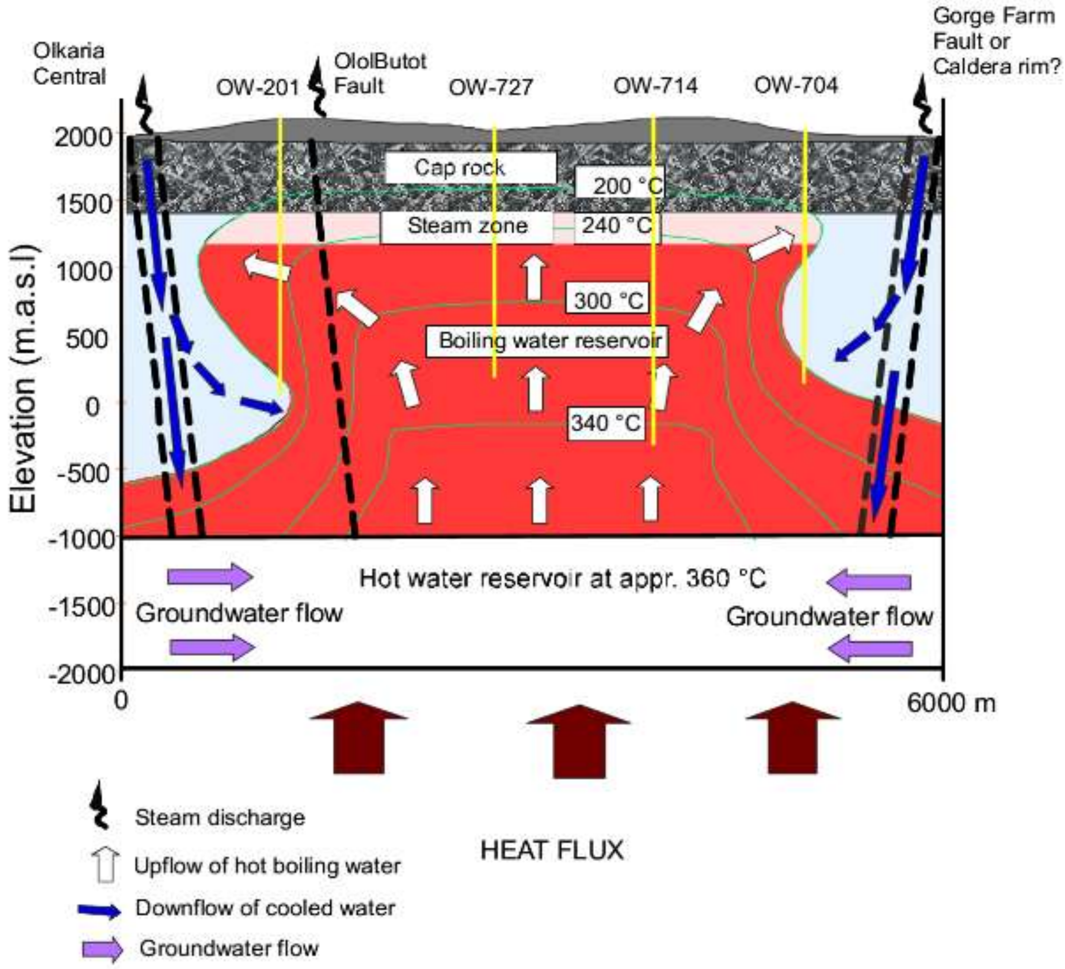

Figure 1: Olkaria conceptual model (Ofwona, 2002)

For conceptual model to be comprehensive to geothermal systems it should be incorporated with the following information's(Axelsson,Mortensen, et al., 2013). Firstly, the size of the system should be provided secondly, the heat source for the system should be explained. Thirdly, the location of the hot up-flow zones should be included. Fourthly, describe the location of colder recharge zones and general flow pattern in a system.The main permeable flow structures (faults,fractures and dykes) should be located in the system with flow barriers and finally the cap-rock and division of system into subsystems and separate reservoirs should be defined.

II. Methodology

Rockworks and windows paint

Geological 3D model was modelled in the study by use of rockworks software. The analyzed geological data was obtained with permission from KenGen management, the data is imported into datasheet in rockworks. In borehole manager choose lithology model to display the lithology model. The 3D model was exported to windows paint where it was edited and modified to locate the heat source, cap-rock and the recharge and discharge zones to create the geological conceptual model. Together with temperature model, lithology and alteration mineralogy a 3D geological conceptual model was created. Rockworks can display lithology data in numerous formats. In this study rockworks17 was used to model the 3D, with procedureoutlined in Figure 2.

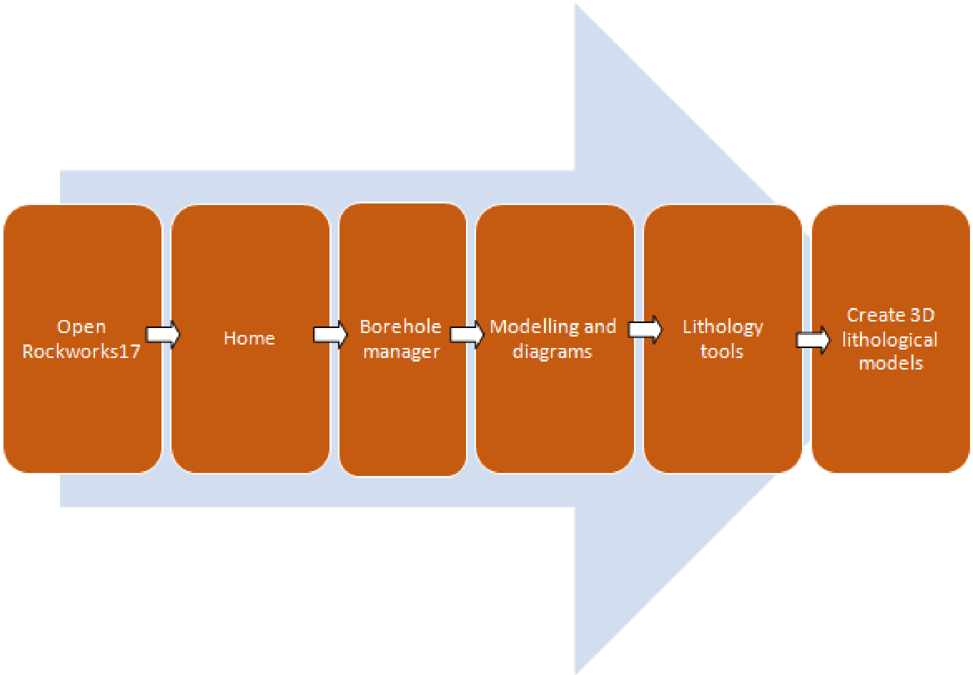

Figure 2: Rockworksflow diagram

III. Results and Discussion

A conceptual model is a very important feature in geothermal energy. When developing the model various disciplinary approaches where parameters from diverse geosciences involved in exploration and development are put together. To construct the model knowledge of heat source, the fluid recharge, the up-flow zones and the cap-rock or impermeable zone, permeable zone or the reservoir is necessary. In this study the interpretation of lithology and geological structures were used to create a geological conceptual model, Figure 3. The diagram shows how geothermal systems exist within the study area. The heat source is located some kilometers below OW 924A with an assumption made regarding existence of intrusions in well OW 924A. The structures (faults, dykes) act as both recharge and discharge zones; it allows percolation of cold water into the system and can discharge through fumaroles, hot spring or through drilling of hot wells to tap the steam.

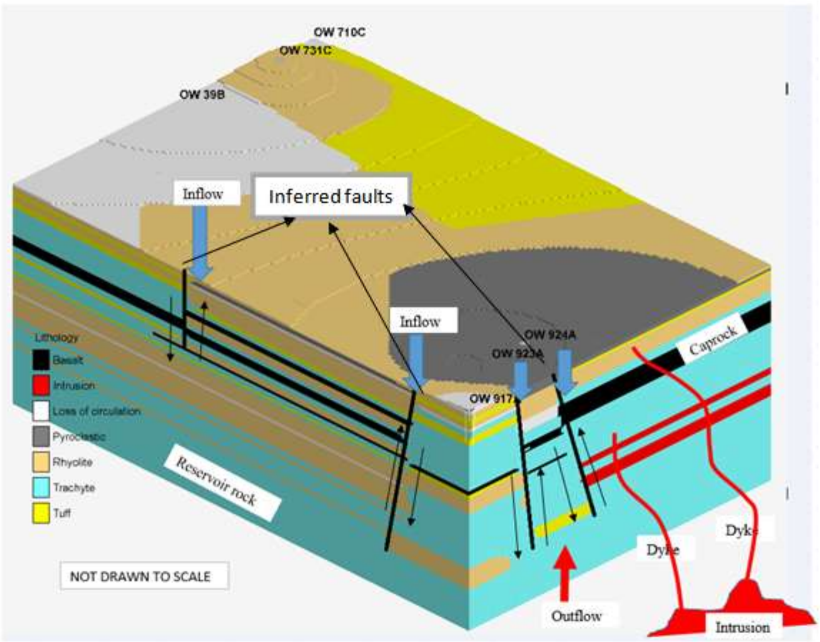

Figure 3: Schematic Geological conceptual model of the study area. The figure is not drawn to scale

IV. Conclusion

The Geological conceptual model shows that trachyte formation forms the reservoir rock of Olkaria geothermal systems. The cap-rocks that overlie reservoirs rocks are the basalts and tuffs confirming suggestion made by Sweco and Virkir on boiling geothermal reservoir enclosed by steam zone controlled on the top by tuffeceous cap rock. Presences of intrusion in the well OW 924A indicates the heat source is near to the geothermal system and finally structures acts as the recharge and the discharge zones the studies is in concur with those made byAxelsson and Mortensen (2013) in above.

The Ololbutot fault structures and the Olkaria fault structure in the study control the productivity of geothermal wells in Olkaria as they form the flow pathways for fluid movement in the system either as recharge zones (Inflow) or discharge (Up-flow) and note that cold inflow zones at shallow depths should be cased off to avoid cooler fluids entering into the reservoir.

References

[1]. Axelsson, G., Arnaldsson, A., Ármannsson, H., Árnason, K., Einarsson, G., Franzson, H., . . . Ouma, P. (2013). Updated conceptual model and capacity estimates for the greater olkaria geothermal system, Kenya. Paper presented at the Thirty-Eighth Workshop on Geothermal Reservoir Engineering, Stanford University.

[2]. Axelsson, G., Mortensen, A. K., & Franzson, H. (2013). Geothermal drilling targets and well siting. Paper presented at the Short Course on Conceptual Modelling of Geothermal Systems, Santa Tecla, El Salvador.

[3]. KenGen. (2014). Stratighaphy logs for well OW-918 and OW-921A. Internal report.

[4]. Kibet, M. K., Magut, P. K. S., & Varet, J. (2019). Rock Types and Alteration Mineralogy Occurring In Olkaria Geothermal Field, Kenya. IOSR Journal of Applied Geology and Geophysics. doi: 10.9790/0990-0701014757

[5]. Mannvit, ISOR, Vatnaskil, & Verkis. (2011). Consultant services for geothermal optimization study of the Greater Olkaria Geothermal Fieds. (pp. 100). Reykjavik.

[6]. Mungania. (1999). Geological report of well OW-714. Kenya Power Company

[7]. Musonye, X. (2015). Sub-surface petrochemistry, stratigraphy and hydrothermal alteration of the domes area, Olkaria geothermal field, Kenya. (MSc), University of Iceland. .

[8]. Ofwona, C. O. (2002). A reservoir study of Olkaria East geothermal system, Kenya. . (MSc), University of Iceland,. (1)

[9]. Omenda, P. A. (1998). The geology and structural controls of the Olkaria geothermal system, Kenya. Geothermics, 27-1, 55-74pp.

[10]. Rop, E. (2013). Interpretation of recent Temperature and Pressure data and updated conceptual model of Greater Olkaria geothermal systems, Kenya. Reykjavik, Iceland.

[11]. Swesco, & Virkir. (1976). Feasibility report for the Olkaria geothermal project. United Nation.

Monicah Kimonda Kibet. " Geological Conceptual Model of Olkaria Geothermal System. "IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG) 7.3 (2019): 25-28