ABSTRACT

Mathematical Modelling and Simulation of Selected Stratigraphy within the Province of Saskatchewan, Canada for Geothermal Energy Prospecting

Randy Rajiv Koon Koon

The focus of this research is to develop a mathematical model that describes the deformation of fracture walls as a function of the fracture radius resulting from the effect of the geothermal fluid flowing through its cavity. Detailed investigations into the Red River and Yeoman Formations, which are used as a template for predicting temperature, deformation and hydraulic analyses for the Winnipeg and Deadwood Formations, are presented. Through the generated mathematical model and utilization of AccuMap well data, the model yields fully solvable analytical solutions for the extent of deformation of individual fracture paths. The research delves extensively into the hydraulic aspects of selective stratigraphy within the regions of Yorkton-Melville, Weyburn East, Melfort-Prince Albert, Moose Jaw-Regina, Estevan East, Estevan West and Central Saskatoon, for geothermal energy prospecting. The work employs a micro-scale realm of fractures to understand the behaviour of fluid flow through such systems and further models of the system are simulated using COMSOL Multiphysics 4.3a.

Useful graphical outputs of all analytical solutions are grouped and plotted with respect to their core number and location in regards to deformation plots. Statistical representation through frequency distribution plots of deformation across the entire region of Weyburn East is acquired. Furthermore, essential 1D plots such as: Permeability, and Darcy's velocity field are extracted from the resultant 3D isosurface Pressure simulations. Therefore, based on the BHTs and temperatures predicted using LTEs, the findings clearly point to the Estevan East region, as the best geothermal energy prospect for Binary systems, having the highest recorded and estimated temperatures at depth as seen in particular with the wells of 141/06-04-006-08W2/02, 101/11-14-002-09W2/00, and 141/03-08-001-11W2/00. In conclusion, the analytical solutions serve to understand systems in response to fluid flow deformation, and based on observed and predicted temperatures values, the Winnipeg and Deadwood Formations are optimal for geothermal energy prospecting within the Sedimentary Basin.

Keywords: Mathematical Modelling; Simulations; Saskatchewan; Geothermal Energy; Canada.