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Thesis Title: Developing a hydrogeological conceptual model for subterranean groundwater control areas using remote sensing and geophysical techniques, Hout catchment, Limpopo, South Africa

Abstract

Crystalline basement aquifers are an important source of water supply in sub-Saharan Africa for various purposes. These aquifers are characterized by fractured rock networks which form pathways for groundwater recharge, flow and discharge in subterranean groundwater areas. The fractured rock networks in these areas form fractured rock aquifers which in some cases are protected or reserved. In a South African context, various aquifers with these characteristics have been declared as subterranean groundwater control areas. The physical characteristics of these hydrogeological settings remains crucial in sustaining ecosystems and supporting socio-economic practices such as irrigation among others. However, fractured rock network systems in subterranean groundwater control areas remain poorly understood. In other words, the role fracture connectivity in crystalline basement aquifers remains poorly understood despite the well-established knowledge about the hydrogeological characteristics of such areas. Based on that problem, the current study described physical hydrogeological characteristics of crystalline basement aquifers using hydrogeological conceptual model in order to demonstrate the influence of connectedness of the fractured rock network system on subterranean groundwater control areas. In the present study argues that comprehensive characterization of fractured rock aquifers is essential in establishing the influence of fracture connectivity on groundwater recharge, flow and discharge especially for subterranean groundwater control areas. The Hout catchment in Limpopo Province of South Africa was used as a case study. To validate that argument, the present study 1] established groundwater potential zones, 2] characterized the hydrostratigraphic system and 3] conceptualized the hydrogeological system. A records review method, remote sensing, geophysical techniques and analytical methods were used to collect and describe geological, hydrostratigraphic, pumping test and water level data in order to characterise the fracture networks and pathways for groundwater flow path assessments. A field experimental site was set up and used for the measurement and analyses of hydrogeological parameters.

Results from thematic mapping of geology, slope, faults, lineament density, drainage density and land cover indicated that areas of high groundwater potential zones were mainly found in southern region of the Hout catchment. Indicators were presence of high borehole yields of 2.5 - 10 l/s that coincided with areas of moderate to high groundwater potential zones of 400 - 700 in the southern region. Using geophysical data, results showed that anomalies (fractured regions) occurred in range of 30m to 72m. Long profiles of four boreholes that were drilled revealed that the area was controlled by highly fractured and weathered Goudplaats granitic gneiss, younger quarzitic rocks and diabase dykes. These observations were in agreement with resistivity graphs that were generated. Findings of the study on drilling showed that water strikes with high blow yields of 5 - 8.4l/s occurred in the deeper regions of the subsurface (30m>) suggesting that water-bearing fractures are present in the area. Transmissivity values from constant rate pumping tests ranged between 36.5 – 48 m^2/d. These high transmissivity values were associated with the fractured nature of weathered pegmatite lineaments and quarzitic-gneissic geology of the Limpopo mobile belt. The water levels in boreholes showed no significant responses to precipitation events which suggested that recharge and flow occur regionally.

A site-specific conceptual model of the aquifer was developed showing the fractured rock network system in the field experimental site. Various datasets such as geophysical and hydrogeological data were used to develop the hydrogeological conceptual model for subterranean groundwater control areas. The model demonstrated the influence of connectivity in fractured rock network systems on subterranean groundwater control areas. The study showed that the use of remote sensing techniques coupled with geophysical and hydraulic parameter estimation methods for groundwater evaluation provided an improved understanding on the influence on fractures and their connectivity on crystalline basement aquifers for water resource and supply.