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Assessment of the fracture networks controlling geothermal fluids in the northern part of the Malawi Rifted Zone

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We investigated the relationship between the geothermal fluids and the fracture networks that control the storage and fluid pathways of geothermal systems in the northern part of the Malawi Rifted Zone (MRZ). The MRZ is a magma-poor rift located in the Western Branch, where potential geothermal energy is postulated from elevated heat flow and the emergence of hot springs through fracture zones. However, there is a lack of knowledge about the fracture networks that control fluid pathways and storage of the geothermal systems in the region.

Preliminary geothermometer calculation studies of hot springs in the MRZ suggested that the highest geothermal reservoir temperatures (200 °C) are found in the northern region. Additionally, the hot springs are associated with the local meteoric water that seeps through deep fracture zones. These structurally-controlled geothermal systems are characterized by geothermal fluids stored in fracture zones with vertical fluid rise (upflows) and/or in shallow sedimentary rocks with horizontal geothermal circulation (outflows) deposited in basins along the MRZ.

The guiding hypothesis is that interconnected regional joints, inherited reactivated structures, and Quaternary faults comprise a complex fracture network that controls the geothermal fluid transport and storage of geothermal systems in the northern part of the MRZ. Therefore, this study aims to quantify the relationship between complex fracture networks and geothermal fluids in this region. Here the term “complexity” means fracture networks that show a wider range of orientations and higher intensity than other areas. We use digital elevation models to map structures, density maps of fracture intensity, and topology characterization to identify surface level connectivity. Additionally, we use high-resolution aeromagnetic data to identify possible conductive structures at depth and the relationship between Precambrian structures and geothermal systems.

The preliminary results show that most of the hot springs in the Karonga area are located in Permian-Triassic and Quaternary basins with ~NNW-SSE fault trends. Also, the hot springs are focused on a region of higher fracture intensity with a favorable setting related to terminations of ~NNW-SSE faults and intersections with reactivated Precambrian foliations (NW-SE). The Chiweta hot spring, the highest reservoir temperature in Malawi, is located at an intersection between NE-SW, N-S, and NW-SE fault systems. Aeromagnetic data shows that most of the hot springs are aligned with the deep conductive structures ~NW-SE oriented of the Karonga Fault Zone (KFZ). The KFZ has been associated with the reactivation of the Precambrian Mughese Shear Zone.

The expectations of this research are: 1) to provide a better understanding of the fracture networks that transport the geothermal fluids, 2) to identify permeable areas to mitigate the high-risk of drilling non-productive wells, and 4) the low-cost methodology used in this study can be applied in similar areas of the Western Branch.