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Bedrock fracture study of the Mount Meager Area: implications to geothermal reservoir characterization

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Summary

Two weeks of field geological and fracture study campaign were held in the Mount Meager area in the summer of 2019. The aim of the study is to improve our understanding of the fracture system and its control on geothermal reservoir in a volcanic belt. Fifty-five stations were made, and 1207 fracture spacing points and 251 fracture attitudes were collected in the field. Data analysis reveals that the fracture pattern in the basement rock differs from the volcanic cover, and that fracture strikes could be location dependent relative to volcanic eruptive centers. At least three types of fractures with different origins and controlled by distinct geological processes are recognized, providing insights for a better understanding of the processes of the volcanic activities and their relationship with the development of the fault/fracture system in reservoir and on the characterization of fracture reservoir.

Method

Traditional methods of geological fieldwork were applied. Field party observes, identifies and records geological and geomorphologic features, measures attitude and spacing of fracture/fault planes, and takes bedrock samples for laboratory analysis/tests. The identified geological and geomorphologic features and evidence of geological processes are analyzed in relation to tectonic and volcanic activities and their impact on reservoir development in and around each station. In addition, a drone was employed to assist the fieldwork by taking aerial photos and searching for suitable sites for setting stations. Outcrop photos were used to digitize fracture traces allowing the characterization of the occurrence, length, distribution, density and spacing used in the construction of for fractured reservoir model.

Data analysis methods include statistics of the measured fracture orientation, dip direction and angle, and estimation of fracture density and other parameters useful for geological synthesis and model development. Various graphic methods were applied to reveal geological trends, spatial variation of geological features and fractures, and correlation between geographic and geological features. Laboratory physical and numerical fracture modelling results were used to guide field data interpretation (e.g., Guo, et al., 2017).

Results and Conclusions

The fracture measurements (attitude, spacing and density) are plotted to depict general strike trends and mechanic relationships among the recorded groups at each station, and to reveal their spatial relationship to volcanic eruption centers, and differences in character between basement rock and volcanic cover collectively. At least three types of fractures of different origins under distinct geological processes are recognized. The plate tectonics related fractures are consistent in character and are common in basement rocks. Their strikes are often in good spatial alignments with volcanic eruption centers and earthquake events; while fractures associated with volcanic doming and eruption activities may vary geographically. They are circular/radial segments and the strikes change spatially depending on their location relative to the eruption center. Volcanic activity may overprint on tectonic fractures. The gravitational fracture is common in the volcanic area and commonly appears parallel to slope. This type of fracture causes instability in the mountain ridge and peak, and can lead to slides and rock avalanche.

Statistics of data analysis shows that the majority of the fractures (>80%) have a spacing of less than 50 cm, and that fracture spacing is slightly greater in the volcanic cover layers than that in the basement rocks in the studied outcrops. Fracture traces measured from photo planes were used to determinate the distribution of fracture length and calculate fracture areal density. Comparison of observed fracture patterns with numerically simulated models with known boundary condition help infer the stress or rock mechanical properties (Guo, et al., 2017).

The southern Meager Creek geothermal reservoir is a fractured crystalline basement consisting of metamorphic rocks and quartz monzonite plutons. A volcanic complex of overlapping andesite, dacite and pyroclastic piles that become progressively younger from south to north overlies on the post-Miocene erosion surface of the basement (Fairbank et al., 1981; Lewis and Souther, 1978). Previous exploration has outlined the potential high temperature geothermal resource prospective area, and subsequent production tests confirmed the presence of a permeable zone that defines the fractured reservoir, although the obtained water flow rate did not justify a commercial power plant (GeothermamEx Inc., 2004; 2009). Nemcok, et al., (2004) in the study of the Karaha-Telaga Bodas geothermal field in the Java volcanic arc showed that fracture systems in reservoir and cap rock were formed under distinct stress regimes and developed in different stages of the volcanic activities. This study provides insights for a better understanding of the volcanic activities and their relationship with the development of the fault/fracture system in reservoir, thus helping better define and characterize the geothermal resource prospect with an optimized resource development strategy.

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