

Analysis of stress heterogeneity in deep fractured crystalline rock

David Sahara and Thomas Kohl

institute of applied Geoscience, Karlsruhe Institute of technology, Germany

The mechanical properties variation, the fracture characteristic and the inclination of the well might perturbed the development of wellbore failures and, hence, affect the estimation of the stress state in fractured rocks. A detailed analysis of 1221 and 827 compressional and tensional wellbore failures, respectively, in a 3.5 km crystalline rock observed in the GPK4 well in Soultz-sous-Forêts enables us to analyze the different pattern of stress heterogeneities which might be related to several factors. The inclination of the well affects the stress distribution by a few MPa which is found to have a significant effect of the development of wellbore, i.e. the limitation of tensile failures in part of the well which is inclined by less than 10° , and the delay of compressional failures occurrence by about 300 m in a 25° inclined well. Fractures and alteration reduced the compressional strength of the crystalline by approximately 30% and, hence, promoted the development of breakout at a smaller far-field stress. The orientation of wellbore failures in such fractured zones are found to be heterogeneously distributed, hence, lower the quality of the stress estimation. Furthermore, the first and second order of stress heterogeneities pattern in the vicinity of major and minor fractures, respectively, in a highly fractured zone at depth 4600 to 4850 m are observed. The numerical modeling of the development of breakouts that take into account the weak zone as a results of fracturing process developed in this study shows a systematic analysis of the variation of the breakout orientation and the reduction of the mechanical properties. In fractured rock, wellbore failures do not correlate to the principal stress only, but also to the variation of the mechanical properties and the properties of fractures. Hence, a long continuous section of wellbore failures is a must to have a sufficient stress-related failures data.