Case study: Dumaguete geothermal field, Negros Island, Philippines

JewelSuite geomechanical modeling helped expand power plant within existing development block

The Dumaguete geothermal field area lies within the tectonically active Philippine archipelago characterized by a complex of subduction zones, collision belts, and marginal basins that define the Philippine Mobile Belt (PMB). The geology of the area is dominated by volcanic rocks with occasional sedimentary and intrusive units, making the reservoirs faulted and intensely fractured.

The Energy Development Corporation (EDC) hosts a 222.5 megawatt (MW) geothermal power plant in the Dumaguete field, and was required to expand due to growing demand of electricity in the region. But the operator lacked adequate wireline log data, particularly bulk density and acoustic data for an optimal well plan. Other challenges included excessive tight holes, lost circulation, and hole filling incidents at shallow depths. Some deeper sections were drilled with less nonproductive time (NPT), but significant blind drilling was encountered at deeper depths due to excessive losses.

The operator required two fundamental objectives: optimize drilling and stimulation strategies for enhanced reservoir production while mitigating risks of circulation losses and gain a better understanding of the fluid flow within the natural fracture network with stimulation to enable of the expansion of the reservoir within its existing permit area.

To achieve the objectives, Baker Hughes was contracted to develop a subsurface geomechanical model, apply this model to a wellbore stability analysis of two planned wells, and characterize the fluid flow through stress sensitive fractures in the reservoir.

Drawing on its field-proven expertise and standing as a world leader in geothermal, Baker Hughes recommended 1D geomechanical modeling, derived from the **JewelSuite™ integrated reservoir modeling software**. This application is an innovative, powerful tool to quickly create precise geological models—regardless of the reservoir's structural complexity—in half the time as traditional solutions. This modeling tool can seamlessly transfer into any industry standard simulator. Reservoir models can be updated and modified easily with new well information or alternative geological scenarios to optimize field development plans and drive greater production.

The safe mud weight window was provided to control borehole breakouts and fluid losses including a quantitative risk analysis (QRA) of uncertainties. Natural fractures were interpreted using image logs from three offset wells. Stress sensitive natural fractures were identified using the 1D geomechanical models and best well designs were identified to intersect the greatest number of

Challenges

- Obtain a better understanding of the fluid flow within the natural fracture network
- Optimize drilling and stimulation strategies for enhanced reservoir production
- Mitigate risks of circulation losses
- Expand the reservoir within its existing permit area

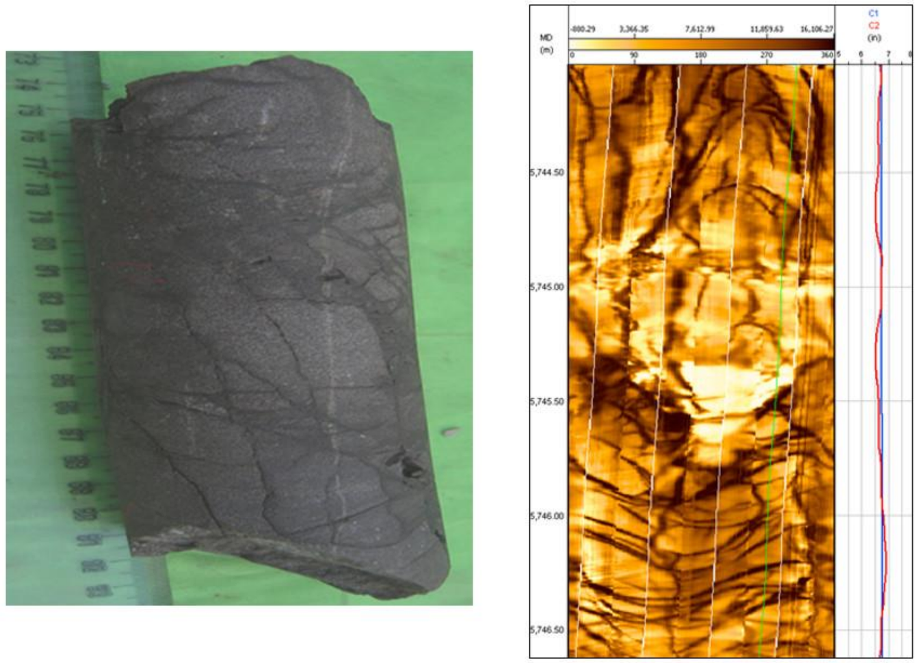
Results

- Developed 1D geomechanical model to characterize natural fractures and fluid flow
- Improved well orientation to access most hydraulically conductive fractures
- Expanded geothermal power plant resource from 222.5 to 282.5 MW
- Experienced no health, safety and environmental (HSE) issues or NPT

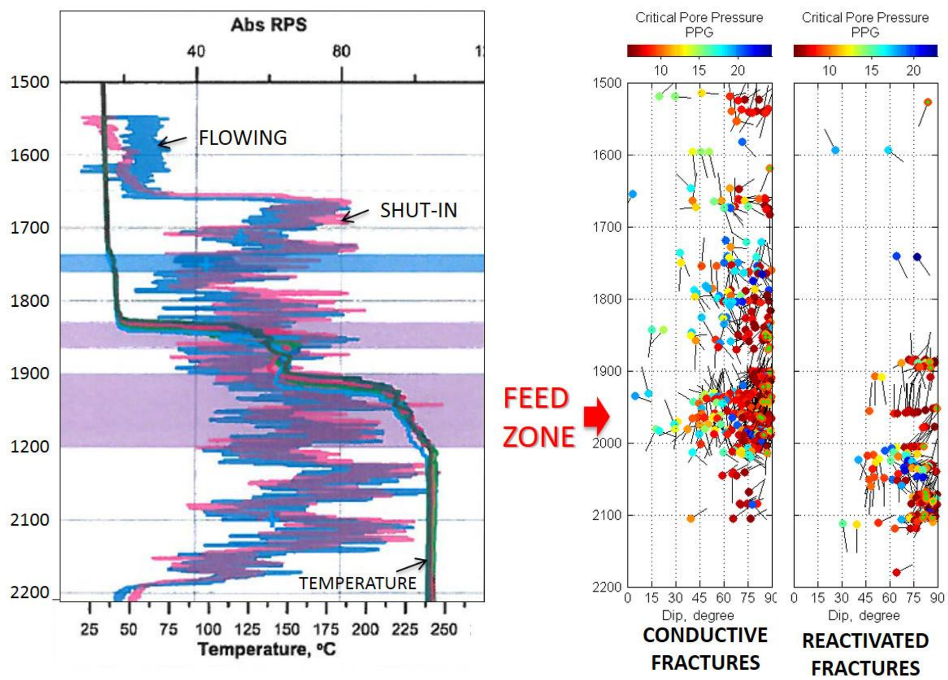
stress-enhanced fractures. Post-drill completion tests were analyzed to model the injectivity of the wells. A revised injectivity test was recommended to establish the sustained permeability of the stimulated fractures with slick water or by injecting slickwater with proppant.

Within the limits of the uncertainties in the geomechanical analysis, data acquisition and operational recommendations were delivered to improve the modeling accuracy and drilling success. The Baker Hughes Reservoir Technical Services team defined the safe mud weight window for the drilling of planned wells. Additionally, the model characterized natural fractures and their contribution to fluid flow.

Equipped with the information from the JewelSuite software, the operator was able to mitigate the drilling risks, discriminate the stress-sensitive natural fractures, and optimize well orientation to penetrate the most hydraulically conductive fractures to enhance production, all with less NPT. With this information, the operator was able to expand this resource by 60 MW.



Fractures detected in wellbore image data are verified against recovered core.



The frictional failure analysis of natural fractures reveals that major feed zones are correlated with critically stressed fractures in well NJ11D.