Case Study

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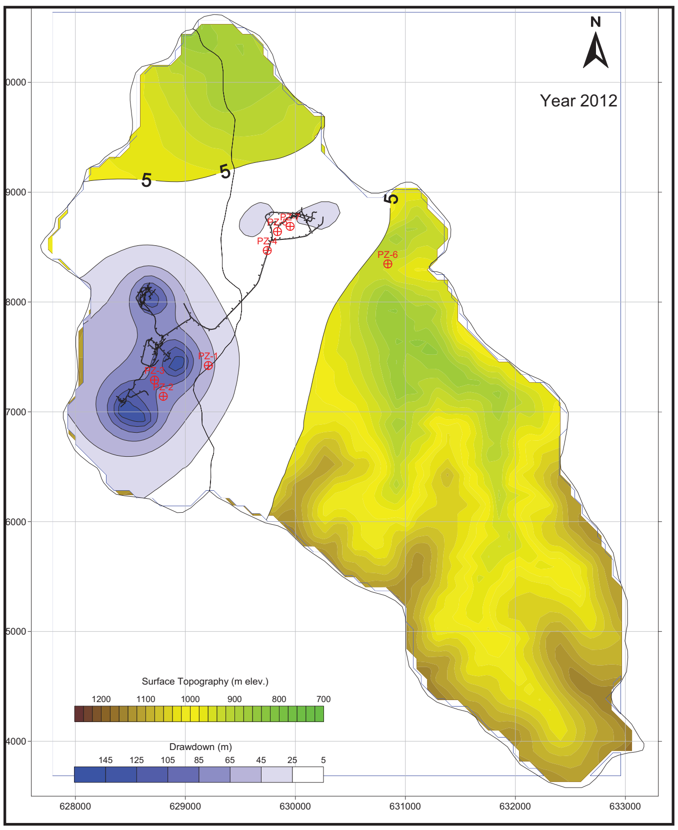
Hydrogeologic Assessment and Numerical Modeling for an Underground Mine

Minas Gerais, Brazil



Modeling drawdowns at Minas Gerais site in Brazil

Highlights:

- Development of conceptual and numerical groundwater flow models to define future inflow rates into an underground gold mine in Minas Gerais State
- Hydrogeochemical assessment to characterize groundwater quality

Background

At the time of this study, the mine was in the exploration and development phase, with a total length of 9.7 km of underground galleries. Mine production was due to start the following year. The mine explores bodies of sulfide gold. The project area is situated within two adjacent sub-catchments, drained by two main creeks, with a combined drainage area of 18.6 km^2. The general flow direction of the water courses is north.

The degree of weathering/oxidation and depth can be related to the fracture frequency, and has been shown to decrease with depth. An assumption was made that the hydraulic conductivity should also decrease with depth. This was demonstrated to be adequate, considering evidence from the mine.

Challenges

- Quantify the probable range of water flow into the underground galleries during the life of the mine
- Quantify the potential changes in average flows of the streams as a consequence of the mining activity
- Calculate the extension of the drawdown area to be induced by groundwater pumping from the mine
- Assess the recovery of groundwater levels at the end of the mine life
- Identify the different types of water in the project area

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Solution

Numerical Model

The hydrogeological context was represented as a three-dimensional block with sub-horizontal, parallel hydrostratigraphic levels. Each level had lower storage coefficients and hydraulic conductivity than the level immediately above. The following hydrostratigraphic horizons were distinguished:

- Oxidized zone (0-50 m): Superficial groundwater flow and strongly influenced by topographic gradients; low to medium hydraulic conductivity (1.0 x10^{-6} m/s) and relatively high storage coefficient (up to 0.1)
- Fractured Zone (50-500 m): Responsible for most of the groundwater flow in the sub-basins; low hydraulic conductivity (5.0 x10^{-7} m/s) and coefficient of storage in the order of 0.01 to 0001
- Non fractured zone (> 500 m): Almost non-existence of interconnected fractures, forms a flow barrier; hydraulic conductivity (2.0 x10^{-7} m/s)

Hydrochemistry

A preliminary hydrochemical assessment was conducted to identify the water types present in different mine sectors.

Results

Numerical Model

The most critical areas of water infiltration were associated with the three southern sectors, where sections of the underground galleries are situated below the streams and their tributaries are connected to the regional structural system.

Model results showed the average flow rate would increase from the current 60 m^3/h to a maximum of 100 m^3/h over the first two years of operation, reducing gradually to stabilize around 85 m^3/h, until turning off the pumps at the end of the mine life, when groundwater levels would start to rebound.

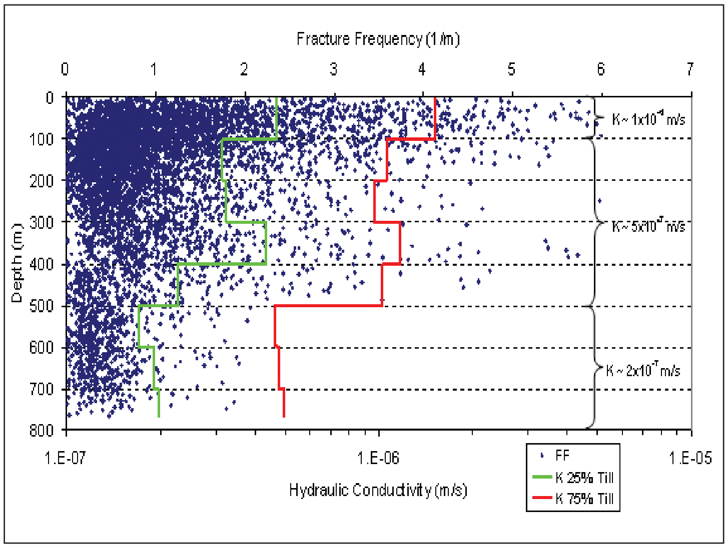
In a conservative approach, it was projected that the cone of drawdown around the mine would spread through the majority of the Western sub-catchment, where most of the mine workings are located, spreading also but less markedly Eastwards, into the adjoining sub-catchment.

The simulations indicated that total flow of the main stream would be affected in less than 5%, meaning the mining operations would have very minimal impact on local streams.

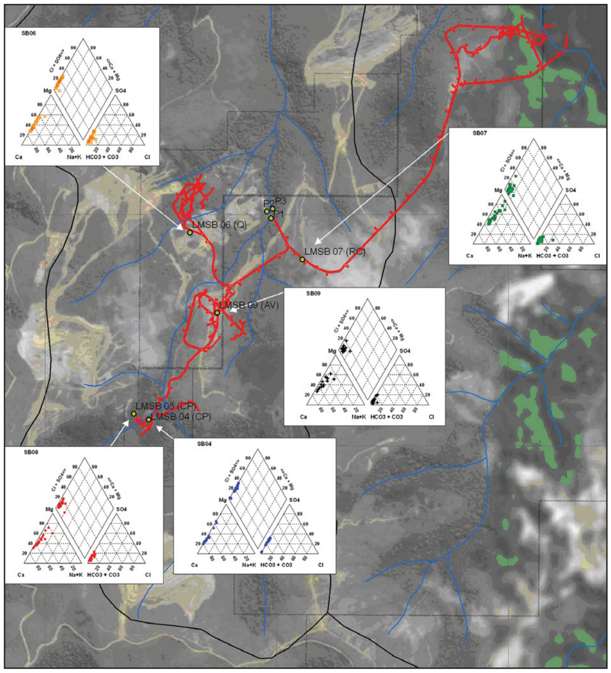
It was determined that the recovery of groundwater levels would occur within 2 to 5 years after mine closure.

Hydrochemistry

The distribution of the hydrochemistry parameters in the project area were illustrated using maps. This distribution was represented by Piper diagrams prepared using Aquachem.



Change in the fractures frequency and hydraulic conductivity with depth



Map illustrating groundwater quality at different mine sectors

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