In a step change beyond traditional processes, Abaqus finite element analysis (FEA) software is being used to enhance mine design and engineering simulation at a number of major mines around the world. In North and South America, Africa, and Australia, some of the world’s biggest mining companies are applying FEA technology to evaluate safety and improve design planning, implementation, and operations.

Beck Arndt Engineering (BAE), a Sydney-based international consultancy, is a pioneer in the commercial development of engineering solutions for the mining industry. The consultancy has worked closely with engineers at SIMULIA Australia to expand the use of Abaqus FEA for mining applications.

Among the early adoptors of mine-ready FEA technology is the world’s largest miner, BHP Billiton. With BAE’s help, BHP has already applied this technology to evaluate mines in Canada and Australia. At the BHP Billiton Nickel West Perserverance Deeps Project in Western Australia, Abaqus FEA software is now being used to help engineer the safety and productivity of planned deep-mining operations.

Using measurements of site deformation and seismicity, Abaqus FEA models have been calibrated and, in a single day, used to simulate a full, three-dimensional, inelastic analysis of a mine’s life cycle.

In recent years, similar applications at Debswana’s Jwaneng Mine in Botswana, the Newcrest Mining Ridgeway Deeps Project in New South Wales, Australia, and Rio Tinto’s Argyle Diamond mine in Western Australia have established Abaqus FEA as the leading technology for multi-scale, simulation-aided mine engineering.

Dr. Joop Nagtegaal, a pioneer in FEA and a Dassault Systèmes Corporate Fellow (retired), says that Abaqus FEA is unique in its capabilities to enable mining engineers to investigate design innovations from the drawing board to full production. “In the design stage, Abaqus models, which include rockmass volumes spanning several kilometers around the ore body and down to excavations just a few metres across, are used to compare and optimize engineering options,” he said. “Then, as the mine goes into production, large volumes of data from the field are incorporated with the analysis models to allow them to be calibrated to a precision not previously available to the mining industry.”
Seismic-event forecasting has become increasingly important at several sites where mining-induced seismicity is a concern. Dr. Stephan Arndt, principal engineer at the BAE Perth office, said the vast amount of analysis required to create solutions in today’s competitive mining markets requires new technologies and methods.

One innovation has been the development of the Dissipated Plastic Energy (DPE) analysis method. DPE analysis has been used to develop controls for potential problems, as well as to better understand how rock masses are damaged (Figure 1).

As the size and complexity of mining problems being studied increase, engineers are facing the need to leverage high-performance computing solutions.

“The size of the models we now use in mining is unprecedented,” said Dr. Arndt. “Distributed Memory Parallel (DMP) processing, using 32 CPUs with Abaqus FEA software, gives us the capacity to compare a number of different scenarios for mine-scale model simulations in a very short time. The level of detail achieved in these models allows us to calibrate deformation and rockmass damage, seismogenic potential, and ground support performance (Figures 2 – 3). Abaqus has an important role to play in mining and our analysis methods are setting new standards in this industry.”

Another application of nonlinear modeling is the design of ground support. Similar to applications in tunneling and civil engineering, mine excavations are subject to high deformation (Figure 4). Not so typical are the strains and loads involved. In some mining cases, tunnels must survive in very weak rock a very short distance from massive underground excavations at great depth.

“Acceptance of FEA technology in mining is similar to the automotive industry experience, in which Abaqus has been accepted as a part of the vehicle body design process,” said Dr. Nagtegaal. “Auto makers have learned that performing crash simulations of their designs with FEA software is much less costly than real-life barrier smashes, and provides a better platform for developing ‘what if’ scenarios. Today, SIMULIA is integrating Abaqus as a tool for simulation-aided mine engineering in much the same way, and with similar achievements in cost savings and improved safety.”

“To ensure the safety of people and to achieve productivity objectives at these challenging sites with unique geological characteristics, mining engineers need to think outside the box,” said Dr. Arndt. “This technology enables quick, cost-efficient analyses, which in turn facilitate the logical decision-making process necessary for the future development of mines in safe, environmentally sound and more economical ways.”