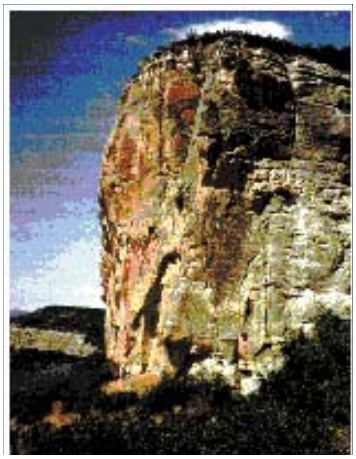
BULLETIN

News from SubTerra, Inc.®

Rockfall Hazard Assessment & Mitigation Twentymile Cliff, Colorado



*The Twentymile Sandstone forms a prominent cliff running for many miles through northwest Colorado. Coal is currently extracted approximately 800 ft. below the cliff top, through longwall mining by the Cyprus Twentymile Coal Company. Earlier subsidence analyses performed by **SubTerra, Inc.**, based on average coal seam extraction thickness, predicted that sections of Twenty-mile Cliff would fail as a result of the undermining operation. This prediction was realized In May 1994, when a section of cliff failed in the western mining district. Fortunately, the failed section was at some distance from the county road and caused no damage. However, concern that similar failures might occur in more hazardous locations prompted Cyprus Twentymile Coal Company to retain **SubTerra** to perform a rockfall hazards analysis.*

SubTerra, contracted to assess potential rockfall hazards due to coal mining beneath Twentymile Cliff, and to recommend appropriate protection measures.

Work began with a site investigation to determine critical parameters for the rockfall analysis. These included the range of potential block sizes that might be released from the cliff, and the nature of the cliff foreslope (topography, roughness, frictional and restitutional coefficients).

Block sizes were assessed using scanline mapping techniques to provide 3D statistical distributions. Certain widely spaced but significant discontinuities were associated with the potential for very large block sizes. This made the stability analysis unique relative to most existing studies.

Twenty critical cliff sections were identified from the site investigation and analyzed using the Colorado Rockfall Simulation Program (CRSP3). Computer models were calibrated through back analysis of the 1994 failure and other known failures along the cliff. For each critical section of cliff, a thousand rockfall scenarios were analyzed. Results were displayed in a contour map of specific risk levels.

Control measures were designed where risk levels were unacceptable. Given the potential size of rock blocks, conventional fences were inadequate; instead, a trap system of trenches and berms was designed.

Based on ***SubTerra*** design recommendations, approximately 3000 ft. of 20-ft. deep trenches were constructed between Twentymile Cliff and the county road to contain falling rocks, requiring realignment of a 1500-ft. section of the road.

A section of cliff subsequently failed due to the mining operation, and a large number of rock blocks were released. Approximately twenty boulders, 10 to 820 tons in size, traversed the foreslope of the cliff and were successfully stopped by the trap system.

The protection measures were constructed in natural soils from the site, and local vegetation quickly obscured their visibility from the county highway. The project received the 1998 Coal Mine Reclamation Division Environmental Award.

PO Box 520; 218 East North Bend Way, North Bend, WA 98045
Phone: (425) 888-5425 info@subterra.us Fax: (425) 888-2725