

August 6, 2018

Mr. Eric Leigh  
Monarch Mountain Minerals and Aggregate  
2660 West 64th Avenue  
Denver CO, 80221

Subject:       Geotechnical/Geologic Hazards Response  
                  Lilly Mines  
                  Highwall Considerations  
                  Gunnison County, Colorado  
                  Project No. 18.5056

Dear Mr. Leigh:

Cesare, Inc. (Cesare) geologists visited the Colorado Marble LLC quarry in the Lilly Mines area of Taylor Gulch off Monarch Pass, Gunnison County Road 228 in Gunnison County, Colorado on July 5, 2018. The purpose of the site visit was to address the highwall stability and associated rockfall and geotechnical hazards, as stated in the Division of Minerals and Geology (DMG) letter dated June 1, 2006. Cesare geologists met with Mr. Eric Leigh, the mining engineer with Monarch Mountain Minerals and Aggregate, to discuss the operations plan going forward.

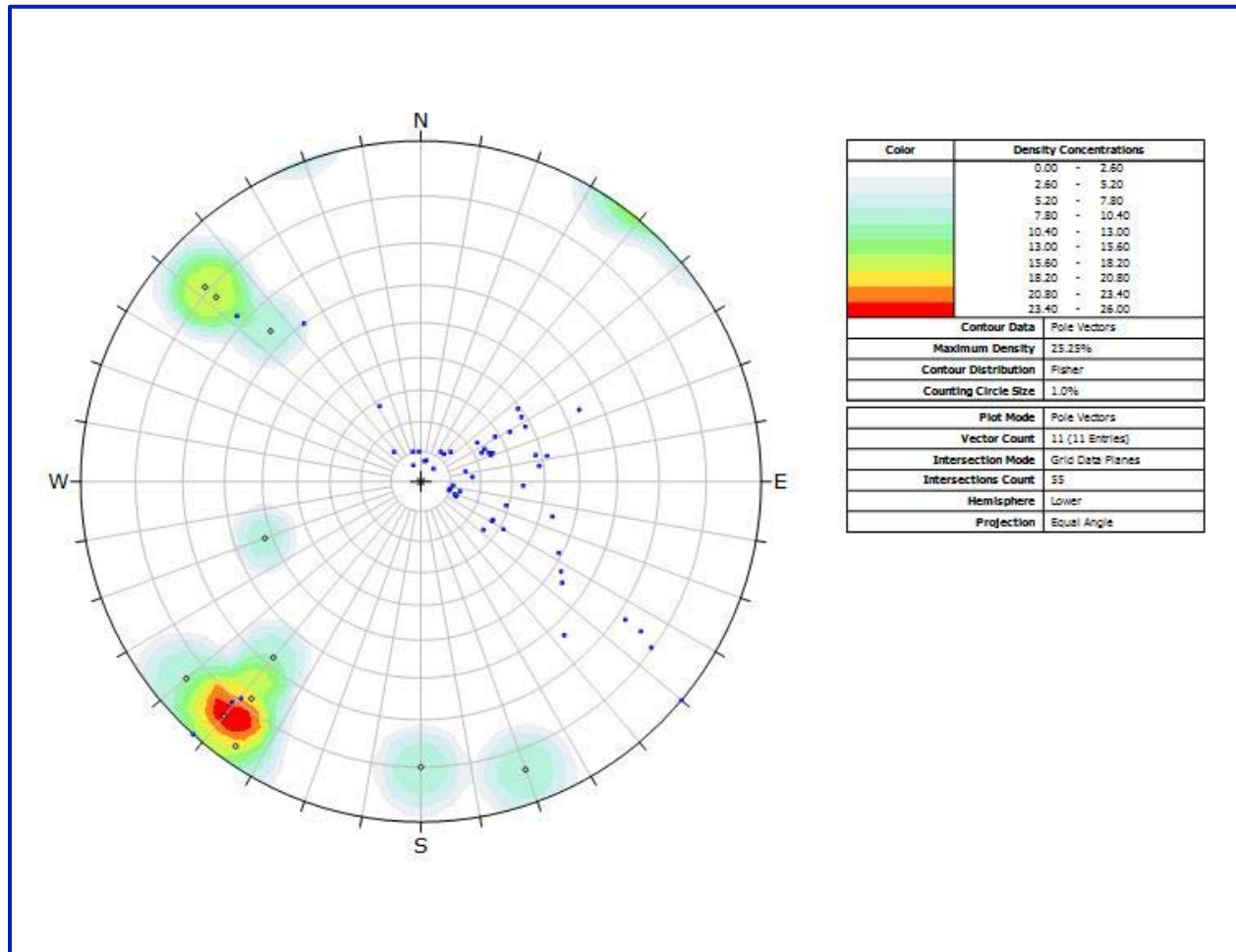
The geology on the western side of the gulch is dominated by north-south striking, steeply dipping sedimentary and metasedimentary units of Paleozoic age, and the eastern side of the valley is dominated by the Silver Plume Granite. There are intrusions of Mount Princeton quartz monzonite in the area. The valley also includes mapped glacial moraine units to the northeast and south. The Paleozoic sequence that outcrops here includes the Manitou Dolomite, the Harding Quartzite, the Chaffee Formation (dolomite, limestone, quartzite), the Leadville Limestone, and the Belden and Minturn Formations (shale, limestone, quartzite) (Geologic Map and Sections of the Garfield Quadrangle, Gunnison and Chaffee Countries, Colorado). The Colorado Marble Quarry follows the north trending outcrops of the Leadville limestone locally metamorphosed into marble.

The marble formation has several major joint sets and fracture patterns. The main joint set was measured as striking N 10E and dipping 75 E. The secondary joint set strikes N 70E and dips 75 NW. This intersecting joint pattern indicates some degree of potential wedge failure of blocks. A third joint set strikes N 40W and dips 84 NE and is susceptible to toppling failure. The marble unit becomes highly fractured in areas along the highwall. The strike of the unit and the strike of the joint sets present provide short term control of the highwall face. Local areas of highly fractured and jointed marble limit the long term stability of the overall rock mass.

### **Lilly Mines Joint Set Analysis**

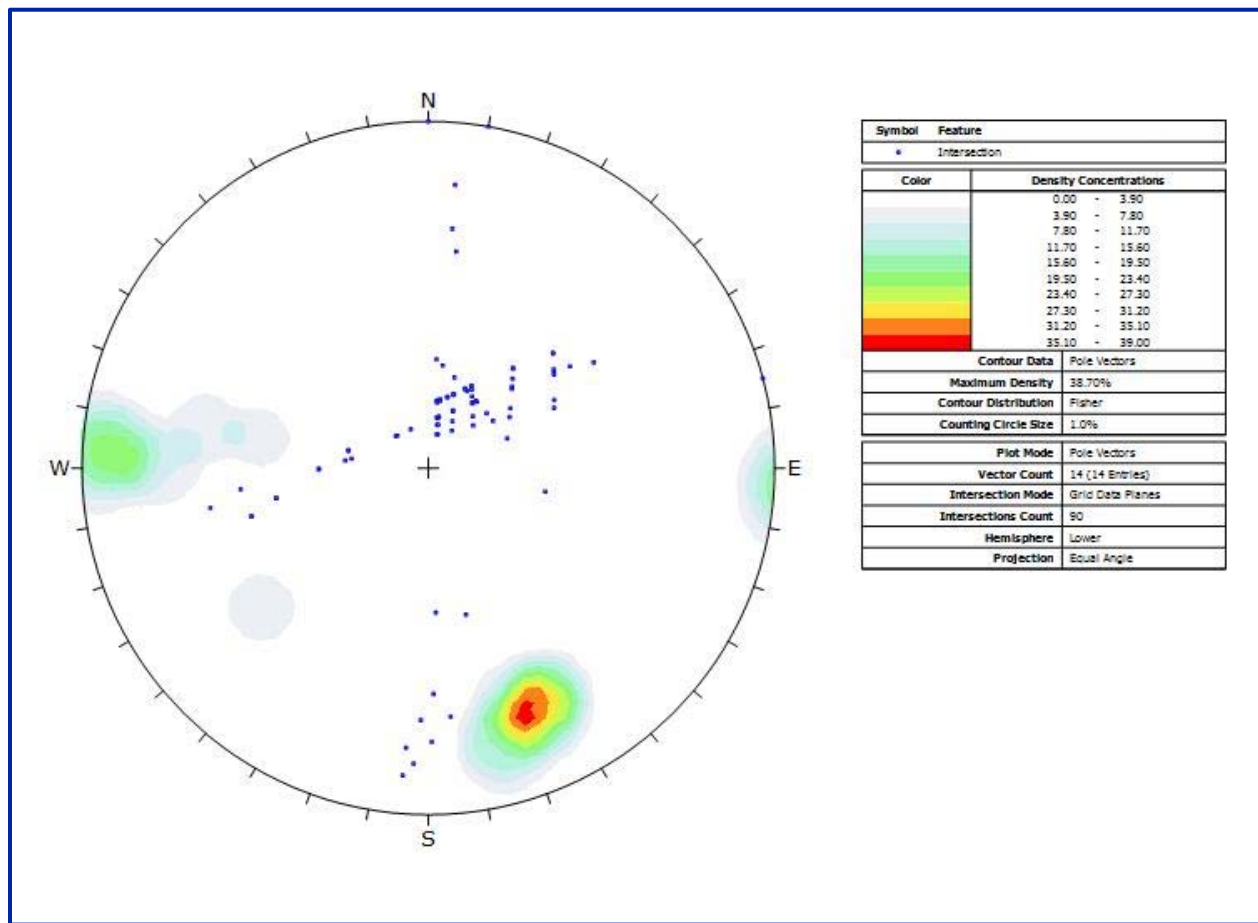
Measurements from the lower bench indicate two major joint sets that intersect the north striking high angle dip of the marble unit to create a wedge pattern (Figure 1). This is visible in the highwall

of the quarry. It has been established that this failure mechanism does not adversely affect the short term control of the rock stability.



**FIGURE 1. Stereonet Plot of Lower Bench Joints**

measurements from the upper bench also indicate two major joint sets that intersect the highwall. The intersections are similar and they create a wedge pattern in the marble unit which daylights in the cut face of the marble. These fracture sets do not affect the short term control of the cut face. Long term control of the failure mechanism in the highwall will be addressed by the backfill plan presented by Monarch Mountain Minerals and Aggregate.



**FIGURE 2. Stereonet Plot of Upper Bench Joints**

The black altered quartzite that outcrops to the west of the white marble bed is exposed along the contact at the top of the highwall. This unit is highly fractured and is a potential source for rockfall into the mine working area.

The lower benches, as projected in the highwall system, will be backfilled with waste rock as mining proceeds to the northern end of the unit. Where backfill of the lower operation area has begun, the angle of repose of the gray dolomite material is 53° and the finer grained gray waste material has an angle of repose of 45°. The plan, as stated by Mr. Leigh with Monarch Mountain Minerals and Aggregate, is for closure of the lower (southern) end of the mine and will include backfilling the excavation area and engineering the resulting slopes to a more natural slope angle using suitable waste rock. The angle of repose of the overburden and rock mix was measured as 28°.

As operations continue along the marble outcrop and new highwall areas are quarried, the recommendation is to update the highwall control plan as new areas are uncovered that may have different joint sets or more highly fractured rock faces.

If you have any questions or comments regarding this information, please contact our office.

Sincerely,  
CESARE, INC.

Holly A. Brunkal, PhD  
Staff Geologist

HAB/ksm

A handwritten signature in blue ink, appearing to read 'D. R. Duran', with a stylized flourish at the end.

Darin R. Duran, P.E.  
Principal, Engineering Manager Mountain  
Division