



## Association of Environmental and Engineering Geologists

### DORMANT LANDSLIDES IN MANCOS SHALE AT CRESTED BUTTE, GUNNISON COUNTY, COLORADO; ORIGIN, HYDROLOGY, MATERIAL PROPERTIES, AND STABILITY

James McCalpin, GEO-HAZ Consulting, Inc.

The Mancos Shale underlies the surface in much of western Colorado, forming badlands landscapes in areas of low precipitation. However, the Mancos also underlies higher elevations (up to 13,000 ft) and the increased precipitation (snow) there causes extensive landsliding. In Gunnison County the heavy laccoliths of Mt. Crested Butte, Snodgrass Mountain, and Gothic Peak lie on a bed of Mancos Shale, the perimeter of which has widely failed in slump-earthflows. Although this landslide terrain makes for interesting skiing, the potential for slide reactivation becomes an issue in Environmental Impact Statements.

The southeast slope of Snodgrass Mountain has been proposed for an expansion of the Crested Butte ski area, with trails to be cut and artificial snow to be added. As part of the pre-EIS studies, we prepared a landslide inventory map of the southeast slope that documents 57 landslides of various sizes (1-20 acres), various ages (recent to pre-latest-glacial), and various movement types; they underlie about half of the slope. Landsliding begins directly at the laccolith/Mancos contact and is controlled by a ca. 60 m-thick transition zone of thin (10-15 m) sills of fractured, granitic porphyry intercalated with the uppermost Mancos. These fractured sills, as well as the fractured zone at the base of the laccolith, deliver large quantities of groundwater into the weak, impermeable Mancos Shale in the transition zone. Landsliding is much less common below the transition zone. Landslide deposits are composed of isolated, gravel-to-boulder-size blocks of porphyry, floating in a matrix of chaotically deformed Mancos Shale.

In order to assess slope stability pre- and post-development, we installed two stream gaging stations, 16 piezometers (some nested) and 7 inclinometers in Spring-Summer 2007. We dug two large trackhoe trenches across suspected toeslope thrusts of the East Slide, the largest slide polygon. The existing network of 9 landslide monitoring stakes installed in 1995 (and measured yearly since then) was increased to 19. Direct-shear and triaxial tests indicate that in-place Mancos Shale has relatively high peak strengths (peak  $\phi=30^{\circ}$ - $40^{\circ}$ ,  $c=200$ - $400$  psf) but much lower residual strengths in previously-failed material ( $\phi=10^{\circ}$ - $11^{\circ}$ ,  $c=0$ - $120$  psf). Overall, Snodgrass is the most-instrumented ski hill in Colorado, and there is no skiing yet!

Landslides of the SE flank show considerable current stability (Factor of Safety,  $FS>1.3$ ) where slope angles are low to moderate, regardless of the morphologic age of the slide (e.g., landslide polygons 9, 11, 22). Development actions are not predicted to decrease the FS below 1.3, according to estimates of hydrologic change due to trail clearing and snowmaking. In contrast, landslides on the steeper slope bands ( $>17^{\circ}$  slopes), have minimum predicted FS of 1.08 to 1.11.

#### MEETING DATE

Thursday  
February 11<sup>TH</sup>, 2010

#### TIME

5:45 p.m. Social Hour  
6:30 p.m. Dinner  
7:30 p.m. Presentation

#### LOCATION

Berthoud Hall,  
Colorado School of  
Mines  
1516 Illinois St.  
Golden, Co 80401  
Room 205  
See Map Below

#### COST

\$25 Members  
\$27 Non-members

#### RESERVATIONS

[meetings@aegrms.org](mailto:meetings@aegrms.org)  
or  
[WWW.AEGRMS.ORG](http://WWW.AEGRMS.ORG)

BY NOON,  
TUESDAY  
February 9<sup>TH</sup>

Where development actions are concentrated, they are predicted to decrease the stability by about half (e.g., in polygon 21, FS 1.11 to 1.05; in polygon 1, FS 1.11 to 1.07; in polygon 14, FS 1.08 to 1.04). In peripheral areas such as the East Slide (a no disturbance zone), the impacts are slight (FS 1.11 to 1.10). Even though slope failure is not predicted to result from the proposed actions, the minimum post-development FS is close enough to 1.0 on the steep slope bands that aggressive mitigation was recommended there (surface water management to decrease runoff and infiltration above the steep slope bands, and horizontal drains to lower the pore pressures on the steep slope bands). However, the S Forest Service requested that about half of the landslide complex be made a “no disturbance” area within the ski area, due to the low factors of safety, and the uncertainties in predicting post-development FS values.

## Upcoming Meetings

March 26 (FRIDAY!)	<b>AEG-RMS Student Night</b>	CSM Berthoud Hall
April 8	<b>AEG-RMS Section Meeting</b> <b>Speaker:</b> Mike West , Michael W. West & Associates <b>Topic:</b> TBD	CSM Berthoud Hall
May 13	<b>AEG-RMS Section Meeting &amp; Family Night</b> <b>Speaker:</b> Vince Matthews, Colorado Geological Survey <b>Topic:</b> TBD	CSM Berthoud Hall

## Student Night 2010

Please see the attached flier for information on being a sponsor for Student Night 2010. A great way to give back to the geological engineering/engineering geology professionals of tomorrow.

**STUDENTS: Start preparing your abstracts now!  
Submission deadline is Monday March 8, 2010**

Submit abstracts to [newsletter@aeqrms.org](mailto:newsletter@aeqrms.org)

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# 31st Annual Short Course on Grouting Fundamentals and Current Practice: Colorado School of Mines, Golden CO June 7-11, 2010

The Colorado School of Mines is hosting the 31th annual short course on Grouting Fundamentals and Current Practice. This course covers injection grouting as a method to improve soil settlement and strength characteristics, and to decrease permeability of soil and rock masses. Major topics covered include properties of cementitious and chemical grouts, procedures for cement and chemical grouting, field monitoring and verification, grouting rock under dams, grouting of rock anchors and micropiles, deep mixing, jet grouting, diaphragm walls, compaction grouting, slab jacking, structural grouting, and grouting for underground structures. Included in the curriculum is a field demonstration of compaction and permeation grouting, flow of ultrafine cement, grout mixing, use of cellular concrete in annular grouting, overburden drilling, grouting of rock anchors, and use of packers.

For detailed course information and registration, visit:  
[http://outreach.mines.edu/cont\\_ed/grouting/index.html](http://outreach.mines.edu/cont_ed/grouting/index.html)

For technical info, contact Scott Kieffer: [kieffer@tugraz.at](mailto:kieffer@tugraz.at)

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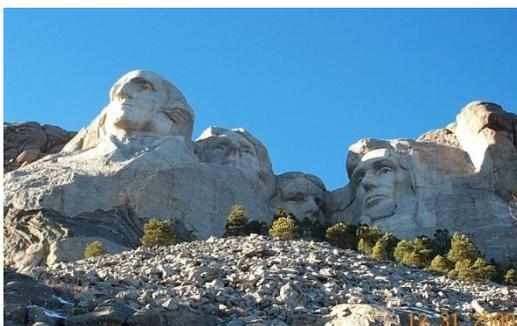
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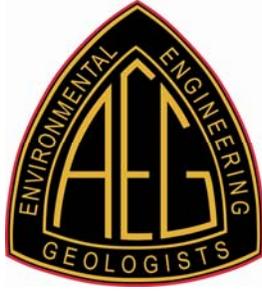
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ASSOCIATION OF ENVIRONMENTAL & ENGINEERING  
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## AEG Student Night

Friday March 26, 2010

5:30-9:00 PM

Berthoud Hall, Room 243

Colorado School of Mines, Golden, CO

The Association of Environmental & Engineering Geologists (AEG) represents professionals in the field of environmental and engineering geology in the greater Denver area and throughout the Rocky Mountain region. AEG is hosting our Annual Student Night Banquet, where environmental and engineering geology students from across the Rocky Mountain region will present their research as part of this well-attended networking event.

We would like to invite you to participate as a sponsor for the event. This will be an exciting opportunity for you to gain recognition for your firm by as many as 100 professionals and students in the region. This event also serves as an excellent recruiting opportunity, as the region's best and brightest students will be in attendance. You may participate at the following sponsorship levels:

### SPONSORSHIP OPPORTUNITIES

<b>Diamond Level</b>	<b>\$400</b>
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<b>Silver Level</b>	<b>\$50</b>
<b>Bronze Level</b>	<b>\$25</b>

All sponsors will be listed on a posterboard at the meeting, in the section newsletter, and on the section website ([www.aegrms.org](http://www.aegrms.org)). All students who attend this meeting receive complimentary admission so this event would not be possible without the support of our sponsors. We thank you in advance for your generous donations!

### RESERVATIONS

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|                          |                        | E-mail          | _____ |

Please RSVP your sponsorship by fax no later than **March 12, 2010**

Fax this form to **720.529.5335, Attn: Julia Frazier**

You may pay for your sponsorship at the meeting, or send a check to:

AEG-RMS

P.O. Box 280663

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# Grouting Fundamentals and Current Practice



**June 7-11, 2010 • Colorado School of Mines**

This course covers injection grouting as a method to improve soil settlement and strength characteristics, and to decrease permeability of soil and rock masses.

Major topics covered include properties of cementitious and chemical grouts, procedures for cement and chemical grouting, field monitoring and verification, grouting rock under dams, grouting of rock anchors and micropiles, deep mixing, jet grouting, diaphragm walls, compaction grouting, slab jacking, structural grouting, and grouting for underground structures.

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