BRIERLEY ASSOCIATES
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"Creating Space Underground"

August 10, 2004
File No. 04030-000

Ms. Juliet Moores
Elk Creek Sand & Gravel
P.O. Box 416
Conifer, CO 80433

Re: Elk Creek Quarry
Geologic and Slope Stability Evaluation

Dear Ms. Moores:

INTRODUCTION

At your request, Brierley Associates LLC (Brierley) has undertaken the scope of work outlined in our proposal dated July 20, 2004 in order to assist Elk Creek Sand & Gravel (Elk Creek) with rezoning negotiations and application with Jefferson County. Our assistance relates to County requirements for geologic information as part of the rezoning package being assembled by Elk Creek and includes stability analysis for future mining and reclamation plans for the site under an existing Division of Minerals & Geology (DMG) 110 Mining and Reclamation Permit (Permit No.M-1978-208).

Brierley proposed to undertake six (6) specific tasks as follows:

Task 1 - Review Existing Information: Review available geologic and geotechnical information in order prepare a Geologic Report without conducting geotechnical investigations other than performing additional geologic mapping.

Task 2 – New Maps: Assemble existing and/or prepare updated site location/topography and geology figures as necessary to accompany our report.

Task 3 – Geologic Mapping: Conduct limited additional geologic mapping at the site to support geotechnical stability evaluations.

Task 4 – Slope Stability Evaluation: Prepare a summary and interpretation of the results of the geologic mapping and perform straightforward slope stability evaluations based on the geologic structure, slope orientation and proposed slope angle.

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Task 5 – Geologic Report: Prepare a brief letter report with accompanying summaries, figures and sketches, as appropriate, to comply with the intent of the County rezoning requirement for submittal of geology information about the site (exclusive of natural radioactivity conditions being handled by Elk Creek as part of a separate rezoning exhibit).

Task 6 – Meetings with JeffCo: Attend two approximately one-hour meetings to accommodate supporting you in ongoing discussions with the County about the geologic and engineering aspects of the project

BACKGROUND

As part of recent County submittals, reviews and requests for additional information, we understand that Elk Creek has been asked to submit a new "Geologic Report" conforming to County guidelines. These guidelines are outlined on pages 27 and 28 of a County guidance document excerpted by you and provided to us for reference. The parameters of the report as outlined therein indicate that the document should include descriptions of, and possible mitigation recommendations for, the following items:

1. General site geology;
2. General site topography;
3. Test borings or core samples;
4. Sites of special geologic interest;
5. Geologic hazards; and
6. Bedrock and surficial geology;

In addition, we proposed to perform additional surficial geologic mapping and general stability analyses to evaluate proposed future mining of the hillside quarry to a slope configuration of approximately 1H:3V using standard stereonet-based stability evaluations. The present scope of our work excluded performing geotechnical investigations such as test borings because we believe that existing site historic information and exposures can be used to adequately describe the elements of the Geologic Report without drilling, sampling or testing.

EVALUATIONS

The following sections provide updated narratives on the six geologic items listed above **(with parenthetic references to County Geologic Report requirements in bold for reference).**

A. General Geology/ Bedrock and Surficial Geology **(G.1.a and G.1.g)**

The site general geology was described in a preliminary geologic evaluation report prepared by F.M. Fox Associates, Inc.[1] at the time of original DMG permitting in 1978. A copy of this document is included as Attachment A for reference. The site is underlain by a thin veneer of hillside colluvium (up to several feet), which is in turn underlain by metamorphic rocks varying from schist to granitic gneiss. The colluvium is Pleistocene to Holocene (Recent) and the bedrock is Precambrian. Pleistocene alluvium reportedly exists at the extreme western edge of the site, but is not of interest because it is west of the active mining operations.

The Fox report appears to be based on the Reconnaissance Geologic Map of the Pine Quadrangle (1:24,000)[2]. A copy of an excerpt from that map showing the project site area is included as Attachment B to this report. The geologic information included in this reference confirms bedrock consisting of migmatitic biotite gneiss with biotite schist, granitic gneiss, and amphibolite. General geologic structure mapped near the quarry includes north to northwesterly striking, easterly to northeasterly dipping foliation and metamorphic compositional layering generally parallel to the foliation. Dips are shallow to moderately steeply dipping, and generally into the hillside at the quarry site.

With respect to the four summary and conclusion items included in the Fox report, Brierley Associates offers the following updated comments:

1. We concur that the site bedrock is composed of compositionally layered metamorphic rocks that include interlayered biotite gneiss, biotite schist, amphibolite and granitic gneiss. These rocks are commonly referred to as the "Idaho Springs Formation" as indicated in the Fox Report, but are referred to as undifferentiated metamorphic rocks of Precambrian Age (1,700 – 1,800 m.y.) on the Geologic Map of Colorado.[3] In addition, because of the migmatitic texture of the predominant gneissic rocks, irregular bodies of rock composed of granitic lithology also occur within the layered metamorphic rock types.
2. We concur that metamorphic foliation is developed parallel to well-developed metamorphic layering, which generally dips moderately steeply into the hillside. The Fox report indicates an easterly dip. Our mapping efforts indicate an average northeasterly dip as discussed further below.
3. We concur that the rocks presently exposed do not exhibit any prominent faulting. We do find there to be mappable jointing in the rock mass, in addition to the foliation jointing. One could argue this jointing is not "prominent" in that it is not continuous over hundreds of feet, there are jointing trends continuous over tens of feet that could affect slope stability as discussed further below.

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[1] Preliminary Geologic Evaluation of a Proposed Aggregate Quarry Site at Shaffer's Crossing, Jefferson County, Colorado; F.M. Fox & Associates, Inc.; May 5, 1978.
[2] Reconnaissance Geologic Map of the Pine Quadrangle, Jefferson County, Colorado; by Bruce Bryant; Miscellaneous Field Studies Map MF-598; U.S. Geological Survey; 1974.
[3] Geologic Map of Colorado; Compiled by Ogden Tweto; U.S. Geological Survey (In Cooperation with The Geological Survey of Colorado); 1979.

4. We concur that the favorable attitudes of the dominant foliation jointing into the hillside is generally compatible with the originally proposed 1:2 (H:V) slope ratio. Additional discussion about slope stability and proposed steepened slopes is included in the slope stability section below.

Finally, the Geologic Map of Colorado (1:500,000) indicates two northwesterly faults transecting or passing just southwest of the site. These faults would be considered inactive and cut across the both the Precambrian metamorphic rocks that occur southeast of U.S. 285 and the slightly younger granitic rocks (Silver Plume Quartz Monzonite and Pikes Peak Granite) that occur northwest of the highway.

B. Site Topography **(G.1.b)**

The site location and topography are discussed in detail in the attached Fox report submitted as part of the original DMG permitting and those details are not repeated herein. Additional comments about site topography for the present rezoning effort include the following:

1. Pre-mining slopes at the site were closer to approximately 2:1 than 2.5:1 as reported in the Fox report.
2. The cut slope along the west side of U.S. 285 across the highway from the quarry is approximately 1:1 overall, and steeper in the lower cut face.
3. Historic mined and reclaimed slopes by others at the site are as steep as 1:2 and appear to be generally stable.

A site topographic map was included in the original DMG permit application. This map is included as Attachment A to this report. The Geologic Map prepared for this report and included in Attachment B also shows the pre-mining topography. In addition, Elk Creek has developed a very detailed site topographic map prepared by Falcon Surveying, Inc. based on a June 2, 2004 field survey. A copy of the new detailed topographic map showing existing conditions (1 in. = 40 ft; 1 ft contour interval) is provided elsewhere in the rezoning submittal.

C. Test Borings or Core Samples **(G.1.c.)**

No test borings were performed and no core samples were obtained as part of original site permitting efforts. Since that time quarry development has occurred and there are ample bedrock exposures at the site to preclude the need for test drilling to identify site lithologies. Topsoil and overburden thicknesses are negligible, varying from less than a foot to approximately 3 ft thick. There is an upper weathered bedrock zone in which moderately severely weathered to completely weathered bedrock extends approximately 15 to 20 ft into the rock mass. Bedrock exposures at the site have been mapped for geologic structure and these data are included in the slope stability section below.

D. Sites of Special Geologic Interest **(G.1.d.)**

There are no known or suspected sites of special geologic interest (e.g., fossil beds) at this site. No features of special geologic interest are anticipated to occur because the site is located within an extensive outcrop of Precambrian metamorphic rocks that are prevalent in the Front Range from west of Colorado Springs north to west of Fort Collins.

E. Geologic Hazards **(G.1.e and G.1.f)**

According to Section 48: G-H of the Jefferson County Zoning, a Geologic Hazard Overlay District has been established to address four (4) types of geologic hazards: slope failure complexes, landslide areas, rockfall areas and subsidence areas. Geologic Hazard Overlay District Zoning Maps have been created to help regulate development in areas susceptible to these geologic hazards.

The Elk Creek Quarry is located in an area well outside (south and west of) any existing Geologic Hazard Overlay District Zoning Maps. Therefore, any concerns about geologic hazards at the site would address unzoned or other geologic hazards. There is no evidence at the site of slope failure, landslide areas or subsidence. Rockfall areas exist as part of the active mining operation within areas that will be completely mined out before establishing final benches and highwalls.

Earthquakes, seismic shaking and liquefaction are not considered to be geologic hazards at the site. The potential for radon gas in this part of the County is beyond the scope of this geologic report and site radioactivity potential is addressed by Elk Creek in another part of the rezoning application.

F. Slope Stability **(G.1.g)**

In order to provide an updated evaluation of slope stability at the site, Brierley performed structural geologic mapping of rock mass discontinuities exposed at the site, and made generalized stability analyses based on these data. Bedrock exposures at the site primarily reveal foliation jointing subparallel to metamorphic compositional layering. The foliation strikes northwest and dips from shallow to moderately steeply to the northeast, generally into the hillside that is being mined. Secondary joints that are steeply dipping to subvertical also occur. Finally, tertiary joints exist that dip northwest to southwest, or generally out of the hillside that is being mined. The foliation joints are persistent across the site. The subvertical joints are persistent for up to 10 to 25 ft. The tertiary joints that daylight in the cut slopes are only persistent on the scale of several feet based on the exposures to date.

The joint mapping data is summarized in both spreadsheet and stereonet format in Attachment C and the following average joint data are interpreted from these mapping data:

Strike	Dip	Joint Designation	Remarks
N33W	35NE	J-f	Foliation (Primary)
N58W	74NE	J-1	Secondary
N54E	75SE	J-2	Secondary
N38W	77SW	J-3	Secondary
N54E	76NW	J-4	Secondary
N27W	41SW	J-5	Tertiary
N20E	40NW	J-6	Tertiary

Stability evaluations for proposed highwall slopes were performed using the average joint orientations listed above. These were based mainly on the primary foliation and secondary steeply dipping joints, but also considered the tertiary daylighting joint sets. Because the tertiary joint sets are not very common or persistent, the two sets were averaged into one westerly dipping orientation for the analyses. Also because of the lack of occurrence and persistence of these tertiary features, they are considered to be relevant only to individual highwall, and not overall slope, stability.

The stereonet analysis and summary included in Attachment D shows potential sliding plane and wedge failures. These all assume continuous, through-going joint features, which is a conservative assumption for this rock mass. Analysis shows potential slope failures if the slope were steepened to 1:4 from the originally proposed 1:2 configuration, but acceptable slope conditions for a quarry development if steepened to 1:3 as Elk Creek is presently proposing (12 ft benches by 35 ft highwalls = 1:2.9).

For slope failures to occur, planar or wedge failures must first be kinematically (geometrically) possible or admissible. In addition, for given possible planar or wedge failure modes, the material strength properties of the rock must be low enough for these failures to be mechanically possible or admissible. Factors of safety less than one were considered as cases where failure was mechanically possible or admissible. Such analyses were run for all kinematically admissible planes and wedges for both weathered and unweathered rock using internal friction angles of 30 degrees and 40 degrees, respectively.

For the proposed 1:3 slopes, our analyses indicate that sliding failure is kinematically admissible only on the averaged westerly dipping joint set, but that this is mechanically admissible only in the upper weathered rock. Toppling failure is not kinematically admissible for any of the six joint sets analyzed. Of five wedge failure modes identified in the analyses, three are kinematically and mechanically admissible in the upper weathered rock, but not in the general rock mass. Two of the wedges might require spot bolting, but limited individual wedge failure in final highwalls is usually considered acceptable in quarry operations. As an example, DMG permitting for the Morrison Quarry in a similar rock mass assumed up to 15 to 20 percent such failures to be acceptable. The upper weathered rock should be laid back to 1:1 for long term stability.

Part of the slope stability analyses included interpretation of rock mass classification and, therefore, strength properties. Summaries of estimated rock mass properties based on rock mass classification schemes (RQD, RMR and Q)[4], as well as on general rock mass type summaries that were used in the analyses are also included in Attachment D.

It is important to note that our analyses were based on the rock mass exposures available for viewing in the quarry during July 2004 and the assumptions detailed in this report. Quarry development should occur as an observational approach whereby initial observations and assumptions are verified periodically during final highwall development and possible adjustments made if future observations reveal conditions significantly different than those assumed to begin with. It is recommended that the operator make and document such periodic observations, either with their own qualified forces, or by retaining a qualified geotechnical practitioner. Should future exposures reveal differing conditions than those described herein, Brierley should be provided the opportunity to verify our analyses, conclusions and recommendations at that time.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are provided to summarize the discussions included in this report:

1. The site is underlain by a thin veneer of hillside colluvium (up to several feet), which is in turn underlain by metamorphic rocks varying from schist to granitic gneiss.
2. General geologic structure mapped near the quarry includes north to northwesterly striking, easterly to northeasterly dipping foliation and metamorphic compositional layering generally parallel to the foliation. Dips are shallow to moderately steeply dipping, and generally into the hillside at the quarry site.
3. Pre-mining slopes at the site were closer to approximately 2:1 than 2.5:1 as reported in the Fox report. The cut slope along the west side of U.S. 285 across the highway from the quarry is approximately 1:1 overall, and steeper in the lower cut face. Historic mined and reclaimed slopes by others at the site are as steep as 1:2 and appear to be generally stable.
4. There is an upper weathered bedrock zone in which moderately severely weathered to completely weathered bedrock extends approximately 15 to 20 ft into the rock mass.
5. There are no known or suspected sites of special geologic interest (e.g., fossil beds) at this site.
6. The quarry is located in an area well outside any existing Geologic Hazard Overlay District Zoning Maps. There is no evidence at the site of slope failure, landslide areas or subsidence. Rockfall areas exist as part of the active mining operation within areas that will be completely mined out before establishing final benches and highwalls.

[4] Rock Classification Systems for Engineering Purposes; Louis Kirkaldie, Editor; ASTM STP 984; 1988.

7. Bedrock exposures at the site primarily reveal foliation jointing subparallel to metamorphic compositional layering. The foliation strikes northwest and dips from shallow to moderately steeply to the northeast, generally into the hillside that is being mined. Secondary joints that are steeply dipping to subvertical also occur. Finally, tertiary joints exist that dip northwest to southwest, or generally out of the hillside that is being mined.
8. Analysis shows potential slope failures if the slope were steepened to 1:4 from the originally proposed 1:2 configuration, but acceptable slope conditions for a quarry development if steepened to 1:3 as Elk Creek is presently proposing (12 ft benches by 35 ft highwalls = 1:2.9).
9. For the proposed 1:3 slopes, our analyses indicate that sliding failure is kinematically admissible only on the westerly dipping joint set, but that this is mechanically admissible only in the upper weathered rock. Toppling failure is not kinematically admissible for any of the six joint sets analyzed. Several wedge failure modes are kinematically and mechanically admissible in the upper weathered rock, but not in the general rock mass. The upper weathered rock should be laid back to 1:1. Limited individual wedge failure in final individual highwalls is usually considered acceptable in quarry operations.

LIMITATIONS

Brierley Associates prepared this report in a manner consistent with the level of care and skill ordinarily exercised by members of the engineering community currently practicing in Colorado subject to the time limits and physical constraints applicable to this report. No other warranty, express or implied, is made.

This report has been prepared for the specific site, development and purpose described to Brierley by Elk Creek. The data, interpretations and recommendations contained herein pertain to this specific project and are not applicable to any other project or site location. Furthermore, they are for the sole benefit of Elk Creek. No other party may use or rely on this report or any portion thereof for other benefit without the express written permission of Brierley.

Slope stability evaluations included in this report are based on the referenced data available at this time and on the proposed slope design by Elk Creek. If, during construction, subsurface conditions are encountered in the future that differ materially from those described in this report, Brierley should be contacted and allowed to review said conditions and reevaluate the conclusions and recommendations provided at this time. If Brierley is requested to provide future assurances about conditions not materially differing from those presently assumed and/or about the stability of final slopes constructed in the future, adequate field review, observation and evaluation by Brierley will be required.

Finally, all conclusions and recommendations about slope stability are based on final slope configurations proposed by Elk Creek and assumed to be constructed in a safe manner with the level of care and skill ordinarily exercised by members of the mining

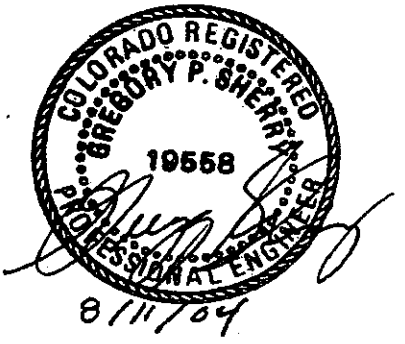
community currently practicing in Colorado. Methods of construction should be such as to ensure the safety of the work, project participants, the public, third parties and adjacent property. All work should conform to the requirements of applicable Federal, State and local laws and regulations. Elk Creek is solely and completely responsible for maintaining safe working conditions at the site at all times.

CLOSING

Brierley Associates appreciates the opportunity to assist Elk Creek with the evaluation and management of this work in progress. We hope this document meets your needs at this time. Please call either of the undersigned if you have any questions, or need any additional assistance with this project.

With best regards,
BRIERLEY ASSOCIATES, LLC

Alan L. Howard
Vice President



Gregg Sherry, P.E.
Vice President

Attachments

ATTACHMENT A

F.M. FOX & ASSOCIATES, INC.
PRELIMINARY GEOLOGIC EVALUATION
MAY 5, 1978

JC 00777
Peterson/Elk Creek

F. M. FOX & ASSOCIATES, INC.
Consulting Engineers and Geologists

4765 INDEPENDENCE STREET
WHEAT RIDGE (DENVER), COLORADO 80033
(303) 424-5578 — FMFOX

PRELIMINARY GEOLOGIC EVALUATION OF A PROPOSED AGGREGATE QUARRY SITE AT SHAFFERS CROSSING, JEFFERSON COUNTY, COLORADO

Prepared For:

Coe, Van Loo and Jaschke Engineering, Inc.

May 5, 1978
Job No. 2161-2530

TABLE OF CONTENTS

SUMMARY AND CONCLUSIONS

No engineering geologic conditions were observed on the site, or are anticipated, which would preclude development of an aggregate quarry. Findings include:

1. The bedrock on the site is composed of compositionally layered metamorphic rocks of the Idaho Springs Formation. Interlayered biotite gneisses, biotite schists, amphibolites and granitic gneisses occur.
2. Metamorphic laminae are well developed and are parallel with a less well developed foliation. Both features dip moderately steeply to the east or back into the hillside.
3. The rocks do not exhibit any prominent jointing or faulting.
4. Favorable attitudes of planar features in the rock, combined with the absence of well developed fracturing, indicate a good cut slope stability for the proposed 1/2 to 1 slope ratio.

LOCATION AND TOPOGRAPHY

The subject property consists of approximately 10 acres of land in the SW 1/4 of Section 32, Township 6 South, Range 71 West, near Shaffers Crossing, Jefferson County, Colorado. The site slopes down to the west at a ratio of about 2.5 to 1 and is bounded by U.S. Highway 285 to the north and Elk Creek to the west. Elevations on the property range from 8,120 feet at the extreme eastern edge to 7,920 feet at the extreme western edge of the site. The slope is fairly uniform from east to west except toward the western third of the property where grading has leveled off a good portion of land (approximately 2 acres) at an elevation of 7,945 feet. Upslope from the graded area moderately dense coniferous vegetation covers the hillside.

SITE GEOLOGY

Most of the undisturbed area of the property is underlain by 0 to 3 feet of colluvial material derived from the underlying bedrock and occuring predominantly as a thin veneer, thickening locally in topographic lows. At the extreme western edge of the site alluvial material, deposited by Elk Creek, is in contact with the hillside colluvium. These surficial deposits are of Quaternary age, the alluvium being Pleistocene and the colluvium being Pleistocene to Holocene (recent).

The bedrock underlying the surficial material is part of the Precambrian Idaho Springs Formation which makes up a large part of the uplifted crystalline rocks of the Front Range of the Central Rocky Mountains. At this particular locality, the Idaho Springs Formation is made up of migmatitic biotite gneiss and biotite schist interlayered with amphibolite and granitic gneiss. The granitic material occurs in numerous layers and lenses throughout the rock. The gneisses and schists are interlayered with the amphibolites and granitic materials to the extent that well developed compositional layering, usually parallel to sub-parallel with a less well developed foliation, is present striking variably from north-south to slightly northwest or slightly northeast. The dip of the compositional layering and the foliation is variable and in places undulating or erratic, but is predominantly 15° to 50° east (back into the hillside). The thickness of the compositional laminae varies from 1/2 inch to 12 inches or more where the granitic gneiss occurs in thick lenses.

Near the surface biotitic gneisses and schists are weathered to the point where they can be scooped out by hand. At depth the degree of weathering decreases but the units are rippable. The amphibolite and granitic gneiss are less susceptible to weathering than the biotitic rocks and are more difficult to excavate. Blasting may be required in localities where amphibolitic

and granitic lithologies predominate. The highly schistose rocks weather to a residuum resembling soil in many characteristics. After denudation and stripping of surficial material and deeply weathered bedrock, the remaining bedrock should be resistant to erosion by running water. No prominent joints or joint sets were observed and no major faults trace through the area.

ANTICIPATED SLOPE STABILITY

The proposed excavation plan calls for benches to be dropped progressively down from east to west with highwalls up to 40 feet high and a slope ratio of 1/2:1. Bench widths will be 20 to 25 feet. The cut slope stability is expected to be good because the compositional layering and the foliation both dip back into the hillside at fairly steep angles and jointing or faulting is substantially absent. These factors will serve to eliminate planes of weakness along which earth and/or rock material could fall, slide or slump downslope. An existing cut immediately east of the graded portion of the site was observed to stand at near vertical angle with little evidence of gravitional movement of earth and rock material.

Without the benefit of exploratory test drilling, it can not be guaranteed that the observed lithologies and structures will persist at depth and laterally into the hillside. However, outcrops observed along the western periphery of the site and considerably upslope (east) from the graded portion of the site exhibited similar characteristics to all other outcrops on the property.

F. M. FOX & ASSOCIATES, INC.

Paul T. Banks

Paul T. Banks, Jr.
Geologist

PTB:klz
Copies: 3

BRUCE A. FLORQUIST REGISTERED 14412 PROFESSIONAL ENGINEER STATE OF COLORADO

Reviewed by:

Bruce A. Florquist

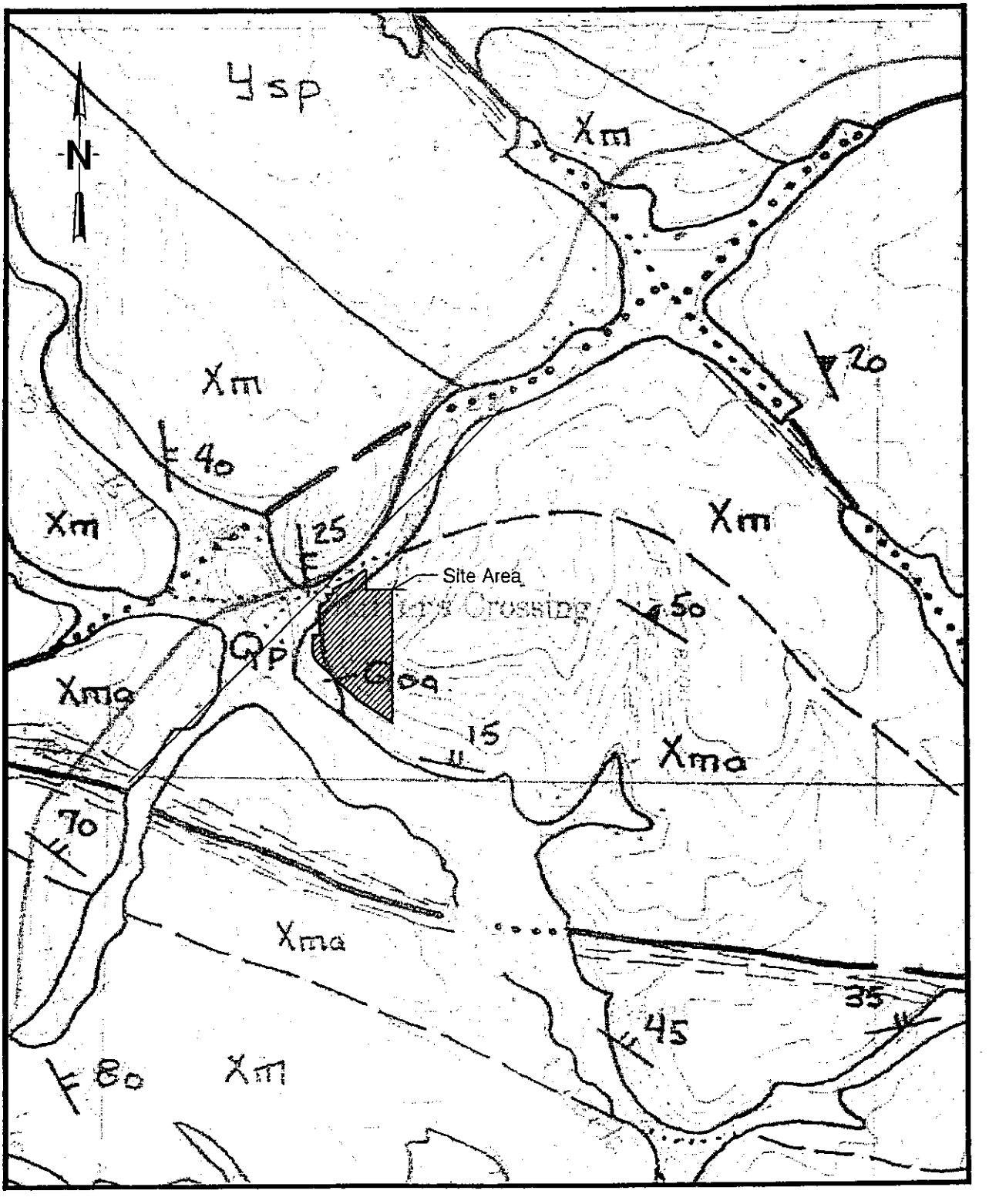
Bruce A. Florquist, P.E.
Vice President

JC 00782
Peterson/Elk Creek

ATTACHMENT B

ELK CREEK QUARRY
GEOLOGIC MAP

JC 00783
Peterson/Elk Creek



APPROXIMATE SCALE: 1" = 1000'

JC 00784

Peterson/Elk Creek

Notes:

1. See attached Explanation Key.
2. From Reconnaissance Geologic Map of the Pine Quadrangle; Map MF-598; by Bryant Bruce; 1974

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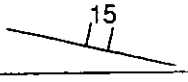
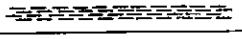
ELK CREEK QUARRY
GEOLOGIC MAP
JEFFERSON COUNTY, COLORADO

JULY 2004

Qp	PINEY CREEK ALLUVIUM (UPPER HOLOCENE) – Dark gray, humic silt, sand and gravel. Cut by narrow gullies along many drainages. Caps terraces about 20 ft (6m) above North Fork South Platte River. Grades to colluvium at heads of valleys.
Qc	COLLUVIUM (UPPER HOLOCENE) – Poorly sorted sand and silt containing angular pebbles and cobbles.
Qoa	OLDER ALLUVIUM (PLEISTOCENE) – Gravel, sand, or silt on terrace 20 to 25 ft (6-8m) above Elk Creek north of Indian Springs Village and on terrace 35 to 40 ft (11-13m) above North Fork South Platte River, center sec. 29, T7S, R71W.
Ysp	SILVER PLUME QUARTZ MONZONITE (PRECAMBRIAN Y) – Coarse-grained to fairly fine grained, muscovite-biotite quartz monzonite. Typical coarse-grained variety has tabular Carlsbad-twinned potassic feldspar phenocrysts to 0.5 to 1 cm long. Locally foliated. Contains numerous inclusions of migmatite. Forms large slabby outcrops and thin sandy soil. Rb-Sr age determinations show that the Silver Plume Quartz Monzonite is about 1,440 m.y. old (Hedge, 1969)
Xm	MIGMATITIC BIOTITE GNEISS (PRECAMBRIAN X) – Biotite gneiss and schist containing numerous layers and lenses of granitic gneiss and some layers of amphibolite, calc-silicate gneiss and quartzite. Locally deeply weathered on gentle slopes in northern part of quadrangle, but forms large outcrops on scarp adjacent to contact of Pikes Peak Granite (Ypp).
Xma	MIGMATITIC BIOTITE GNEISS AND AMPHIBOLITE (PRECAMBRIAN X) – Biotite gneiss and schist containing numerous layers and lenses of granitic gneiss. Amphibolite and biotite-plagioclase gneiss make up 10 to 20 percent of the unit.
	CONTACT – Generally inferred or approximately located. Dashed where indefinite; dotted where concealed.
	STRIKE AND DIP OF FOLIATION
	STRIKE AND DIP OF COMPOSITIONAL LAYERING Generally parallel to foliation.
	Indicates presence of numerous shears or fractures.

JC 00785
Peterson/Elk Creek

Notes:
1. From Reconnaissance Geologic Map of the Pine Quadrangle; Map MF-598; by Bryant Bruce; 1974

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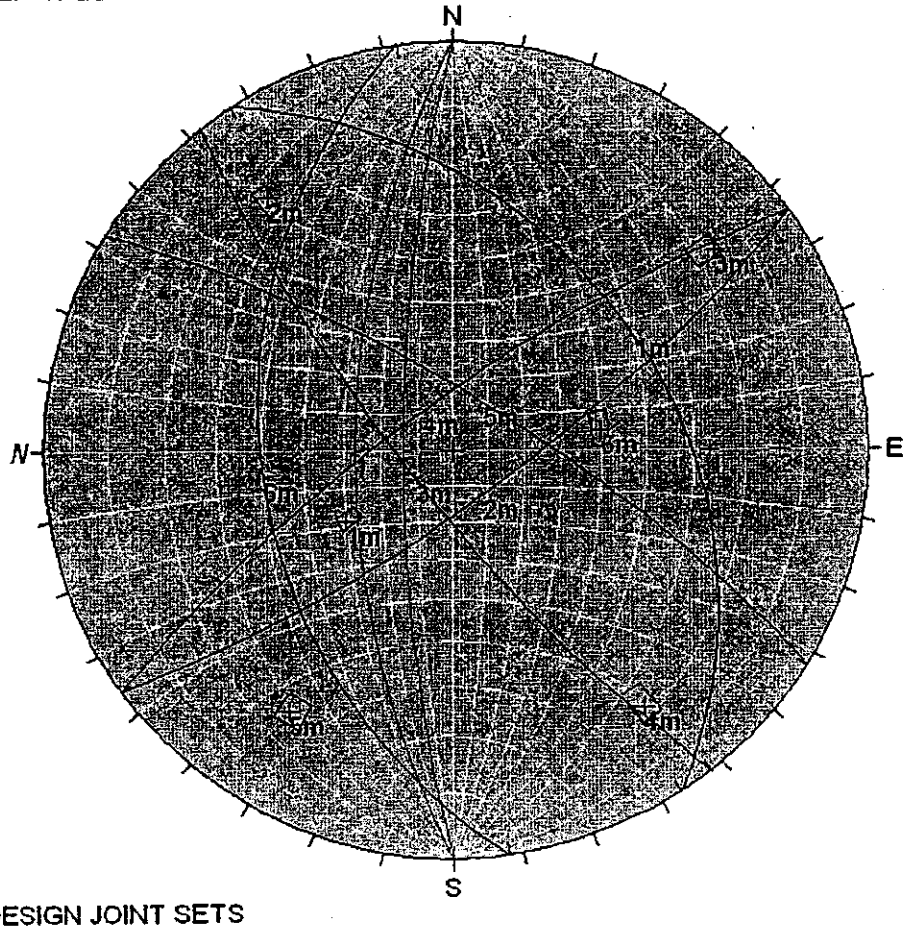
ELK CREEK QUARRY
GEOLOGIC MAP
EXPLANATION KEY
JEFFERSON COUNTY, COLORADO
JULY 2004

ATTACHMENT C

ELK CREEK QUARRY
GEOLOGIC MAPPING DATA

ELK CREEK QUARRY



DESIGN JOINT SETS

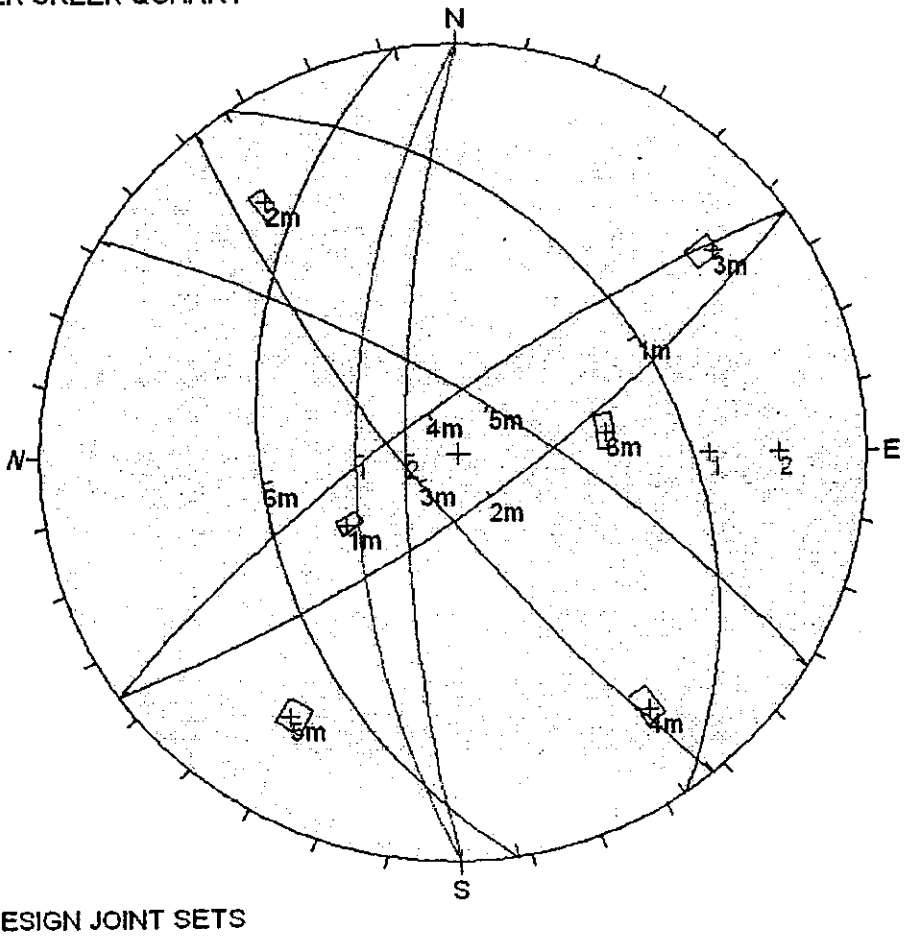
Orientations

ID		Dip / Direction
1		63 / 270
2		76 / 270
1	m	35 / 057
2	m	75 / 144
3	m	77 / 232
4	m	76 / 324
5	m	74 / 032
6	m	40 / 262

Equal Angle
Lower Hemisphere
6 Poles
6 Entries

JC 00787
Peterson/Elk Creek

ELK CREEK QUARRY



DESIGN JOINT SETS

Orientations

ID		Dip / Direction
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2		76 / 270
1	m	35 / 057
2	m	75 / 144
3	m	77 / 232
4	m	76 / 324
5	m	74 / 032
6	m	40 / 262

Equal Angle
Lower Hemisphere
6 Poles
6 Entries

JC 00788
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Elk Creek Quarry
Surficial Mapping
Joint/Discontinuity Data

ALH Updated 8/2/2004

Azimuth	Dip Angle	Dip Direction	Remarks
7	32	97	Foliation
355	26	85	Foliation
145	33	55	Foliation
10	30	100	Foliation
345	40	75	Foliation
355	24	85	Foliation
330	32	60	Foliation
5	38	95	Foliation
315	35	45	Foliation
309	23	39	Foliation
20	26	110	Foliation
125	51	35	Foliation
344	40	74	Foliation
325	23	55	Foliation
0	46	90	Foliation
175	16	85	Foliation
315	46	45	Foliation
135	38	45	Foliation
315	24	45	Foliation
135	60	45	Foliation
130	35	40	Foliation
110	34	20	Foliation
134	43	44	Foliation
150	34	60	Foliation
115	28	25	Foliation
112	47	22	Foliation
128	40	38	Foliation
125	30	35	Foliation
150	24	60	Foliation
100	44	10	Foliation
AVE	35	57	Average Foliation (J-f)

Azimuth	Dip Angle	Dip Direction	Remarks
105	54	15	
130	85	220	
255	64	345	
73	72	343	
158	80	248	
45	73	135	
136	84	226	
175	75	265	
144	40	234	
35	39	305	
310	85	40	
310	85	220	
289	73	19	
38	85	128	
38	85	308	
335	85	245	
300	67	210	
45	85	135	
45	85	315	
77	82	347	
55	80	145	
310	52	220	
5	40	275	
322	38	232	
322	85	52	
17	67	287	
85	52	175	
174	44	264	

Dip Angle	Dip Direction					
54	15	J1				
73	19	J1				
85	40	J1				
85	52	J1				
74	32	Average J1				
85	128	J2				
85	135	J2				
73	135	J2				
80	145	J2				
52	175	J2				
75	144	Average J2				
67	210	J3				
85	220	J3				
85	220	J3				
52	220	J3				
84	226	J3				
85	245	J3				
80	248	J3				
75	265	J3				
77	232	Average J3				
38	232	J5				
40	234	J5				
44	264	J5				
41	243	Average J5				
40	275	J6				
39	305	J6				
40	290	Average Jf	(	40	262	Average J5+J6))
67	287	J4				
85	308	J4				
85	315	J4				
72	343	J4				
64	345	J4				
82	347	J4				
76	324	Average J4				

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ATTACHMENT D

ELK CREEK QUARRY
SLOPE STABILITY
EVALUATION INFORMATION

JC 00790
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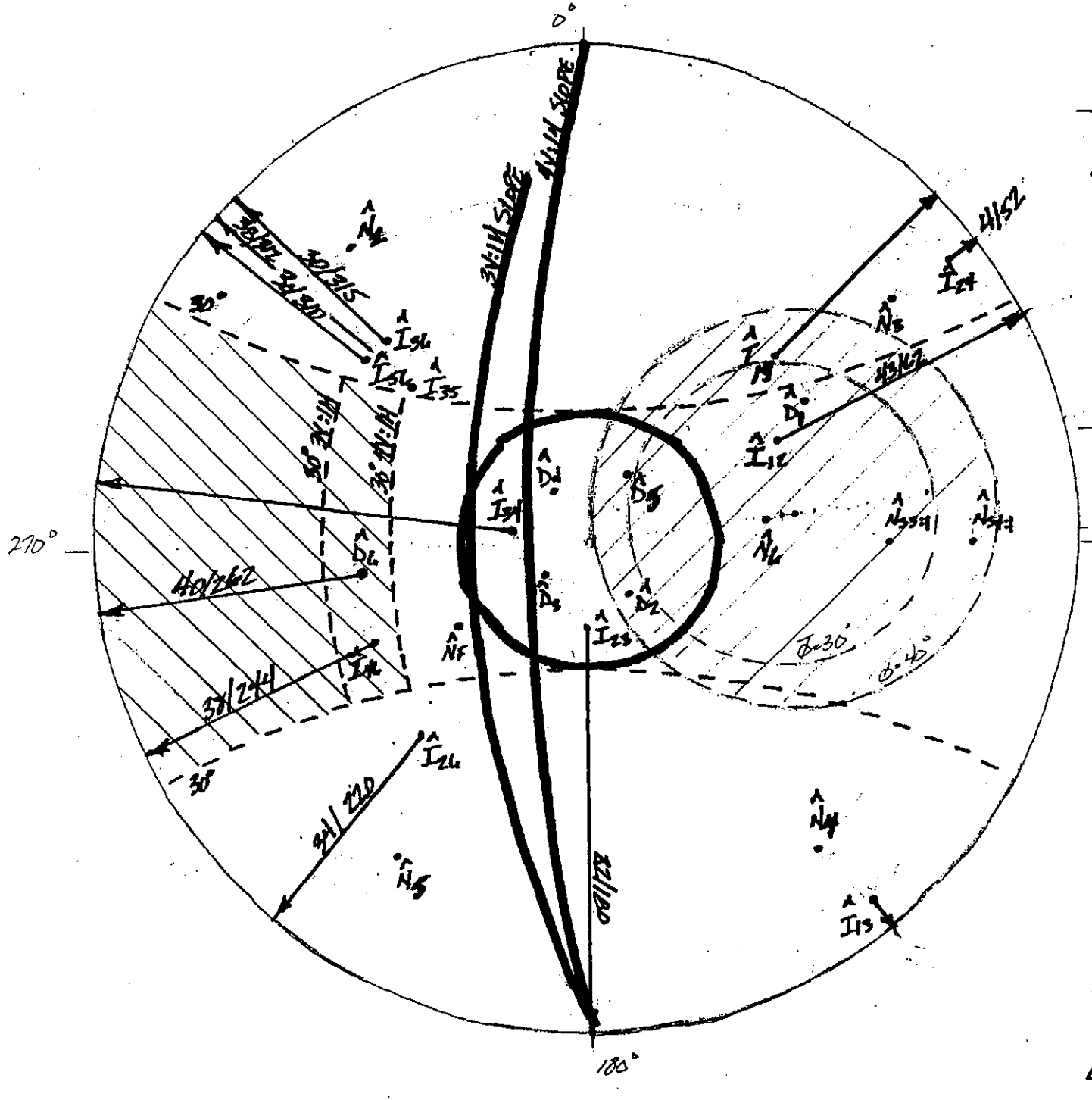

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POTENTIAL SLIDING PLANES

IDENTIFICATION NUMBER	DIP (DEG.)	DIP DIRECTION (DEG.)	$FS_{GSI=30}$	$FS_{GSI=50}$
$\hat{D}_L$	40	262	<1.0	>1.0
$\hat{I}_{3L}$	30	315	>1.0	>1.0
$\hat{I}_{3S}$	38	312	<1.0	>1.0
$\hat{I}_{SL}$	30	310	>1.0	>1.0
$\hat{I}_{4L}$	38	244	<1.0	>1.0
$\hat{I}_{2L}$	34	220	<1.0	>1.0

$FS = \frac{TAN\,\phi}{TAN\,\psi}$ $\quad GSI = 30$ $\quad \phi = 31°$ $\quad C = 200\ PSI$

$GSI = 50$ $\quad \phi = 45°$ $\quad C = 330\ PSI$

CONCLUSIONS:

1. TOPPLING IS NOT KINEMATICALLY OR MECHANICALLY ADMISSABLE FOR THE 6 MAPPED JOINTS.
2. SLIDING ALONG JOINT NO. 6 IS KINEMATICALLY AND MECHANICALLY ADMISSABLE IN THE UPPER WEATHERED ZONE. WITHIN THE GENERAL ROCK MASS, SLIDING ALONG JOINT No 6 IS KINEMATICALLY ADMISSABLE BUT MECHANICALLY INADMISSABLE GIVEN ITS PERSISTENCE AND THE STRENGTH PARAMETERS OF THE ROCK MASS.
3. WEDGES CREATED BY $\hat{I}_{3S}$ $\hat{I}_{4L}$ & $\hat{I}_{2L}$ ARE KINEMATICALLY & MECHANICALLY ADMISSABLE WITHIN THE CUT FACE BUT NOT THE GENERAL MASS.
4. SPOT BOLTING MAY BE REQUIRED FOR $\hat{I}_{3S}$ & $\hat{I}_{4L}$

ELK CREEK QUARRY
ROCK MASS CLASSIFICATION EVALUATION

ALH
7/27/2004

	UPPER WEATHERED ROCK	GENERAL ROCK
1. RQD (Estimated - No Core Data)	VERY POOR TO POOR (SAY VERY POOR)	POOR TO GOOD (SAY FAIR)
2. RMR		
A1	2 (5-25 MPa)	7 (50-100 MPa)
2	3 (<25%)	13 (50-75%)
3	8 (60-200mm)	10 (200-600mm)
4	10 (Discontinuity Condition)	25 (Discontinuity Condition)
5	15 (Dry)	15 (Dry)
B	0 Very Favorable/Slopes	0 Very Favorable/Slopes
C	**38 Class IV (Poor Rock)**	**70 Class IV (Good Rock)**
D	**25 Estimated Friction Angle**	**40 Estimated Friction Angle**
3. Q'		
RQD	15	70
Jn	17	10
Jr	3	3
Ja	4	2
Jw	1	1
SRF	1	1
Q'	**0.66 (Very Poor)**	**10.50 (Fair to Good Rock)**
4. GSI	**35 Disintegrated to Blocky/Disturbed w/ Very Poor**	**65 Very Blocky w/Good to Fair**
	33 (Check; RMR-5)	65 (Check; RMR-5)

JC 00793
Peterson/Elk Creek

Elk Creek Quarry

Input Parameters	
q_u	*10000 psi*
m_i	*25*
GSI	*50*
m_b	4.2
s	0.0039
a	0.5
σ_{tm}	-9.22 psi
A	0.74
B	0.72
k	4.52
ϕ'	39.6
c'	520.0 psi
σ_{cm}	2212.3 psi

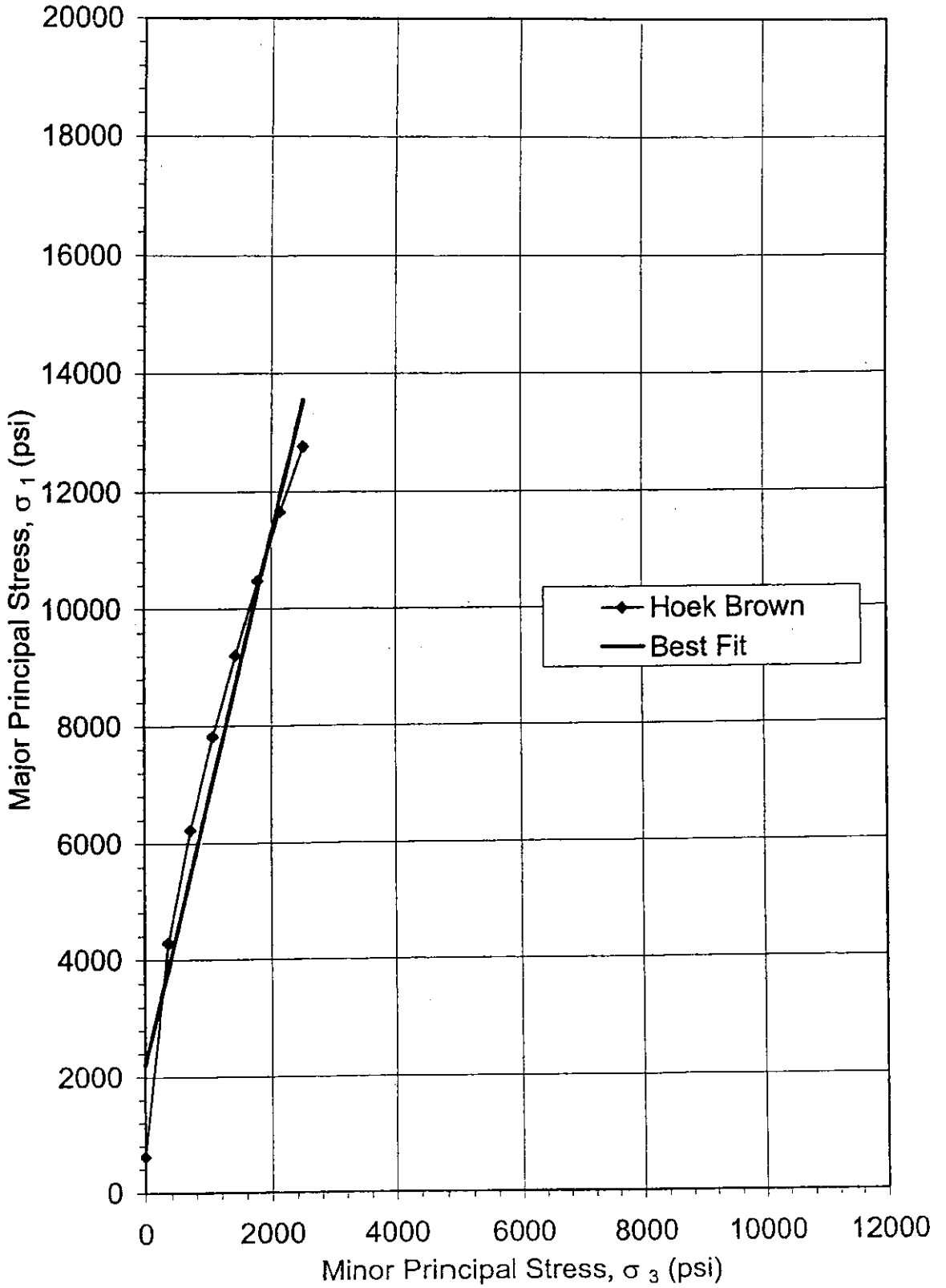
Hoek-Brown Equivalent Mohr-Coulomb Failure Criteria

									Sum
σ_3	0	358	716	1074	1432	1790	2148	2506	10024
σ_1	622	4281	6230	7813	9205	10475	11657	12774	63056
$\delta\sigma_1/\delta\sigma_3$	34.7	6.3	4.8	4.1	3.7	3.4	3.2	3.0	63.3
σ_n	17	892	1666	2393	3087	3758	4410	5047	21270
τ	103	1346	2083	2673	3182	3636	4049	4431	21502
x	-2.6	-1.0	-0.8	-0.6	-0.5	-0.4	-0.4	-0.3	-6.6
y	-2.0	-0.9	-0.7	-0.6	-0.5	-0.4	-0.4	-0.4	-5.8
xy	5.1	0.9	0.5	0.4	0.3	0.2	0.1	0.1	7.6
x^2	6.6	1.1	0.6	0.4	0.3	0.2	0.1	0.1	9.4
$\sigma_3\,\sigma_1$	0	1532770	4460461	8390669	13181147	18749522	25040161	32012201	#########
σ_3^2	0	128164	512656	1153476	2050624	3204100	4613904	6280036	17942960
σ_1 fit	2212	3832	5452	7072	8692	10312	11932	13552	
τ fit	534	1259	1901	2502	3078	3633	4174	4702	

Summary	GSI = 50
q_u	10000 psi
ϕ'	39.6
c'	390 psi
σ_{cm}	1659 psi
σ_{tm}	9.22 psi

Rock Mass Parameter Summary

mi =	25		c'	σ_{tm}	E_{rm}	G_{rm}	K_{rm}
RQD	**GSI**	**ϕ'**	**(psi)**	**(psi)**	**(psi)**	**(psi)**	**(psi)**
0 to 25	20	31	198	0	214160	82369	178467
25 to 50	30	34	287	2	380837	146476	317364
50 to 75	40	37	332	4	677235	260475	564362
75 to 90	50	40	390	9	1204312	463197	1003594



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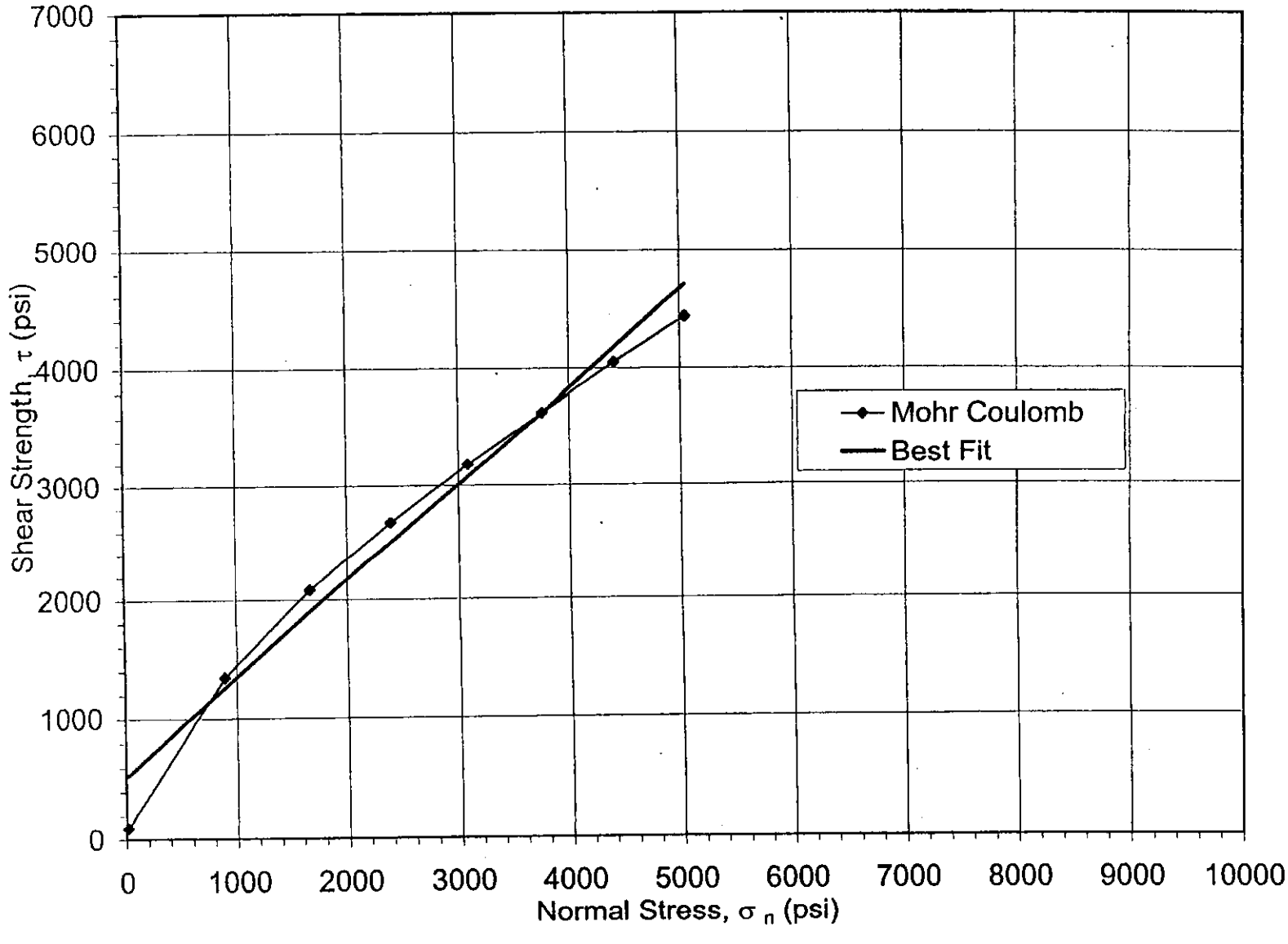

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Table 11.3: Values of the constant m_i for intact rock, by rock group. Note that values in parenthesis are estimates.

Rock type	Class	Group	Texture			
			Coarse	Medium	Fine	Very fine
SEDIMENTARY	Clastic		Conglomerate (22)	Sandstone 19	Siltstone 9	Claystone 4
				Greywacke (18)		
	Non-Clastic	Organic		Chalk 7		
				Coal (8-21)		
		Carbonate	Breccia (20)	Sparitic Limestone (10)	Micritic Limestone 8	
		Chemical		Gypstone 16	Anhydrite 13	
METAMORPHIC	Non Foliated		Marble 9	Hornfels (19)	Quartzite 24	
	Slightly foliated		Migmatite (30)	Amphibolite 25 - 31	Mylonites (6)	
	Foliated*		Gneiss 33	Schists 4 - 8	Phyllites (10)	Slate 9
IGNEOUS	Light		Granite 33		Rhyolite (16)	Obsidian (19)
			Granodiorite (30)		Dacite (17)	
	Dark		Diorite (28)		Andesite 19	
			Gabbro 27	Dolerite (19)	Basalt (17)	
			Norite 22			
	Extrusive pyroclastic type		Agglomerate (20)	Breccia (18)	Tuff (15)	

* These values are for intact rock specimens tested normal to bedding or foliation. The value of m_i will be significantly different if failure occurs along a weakness plane.

In deciding upon the value of σ_{ci} for foliated rocks, a decision has to be made on whether to use the highest or the lowest uniaxial compressive strength obtained from