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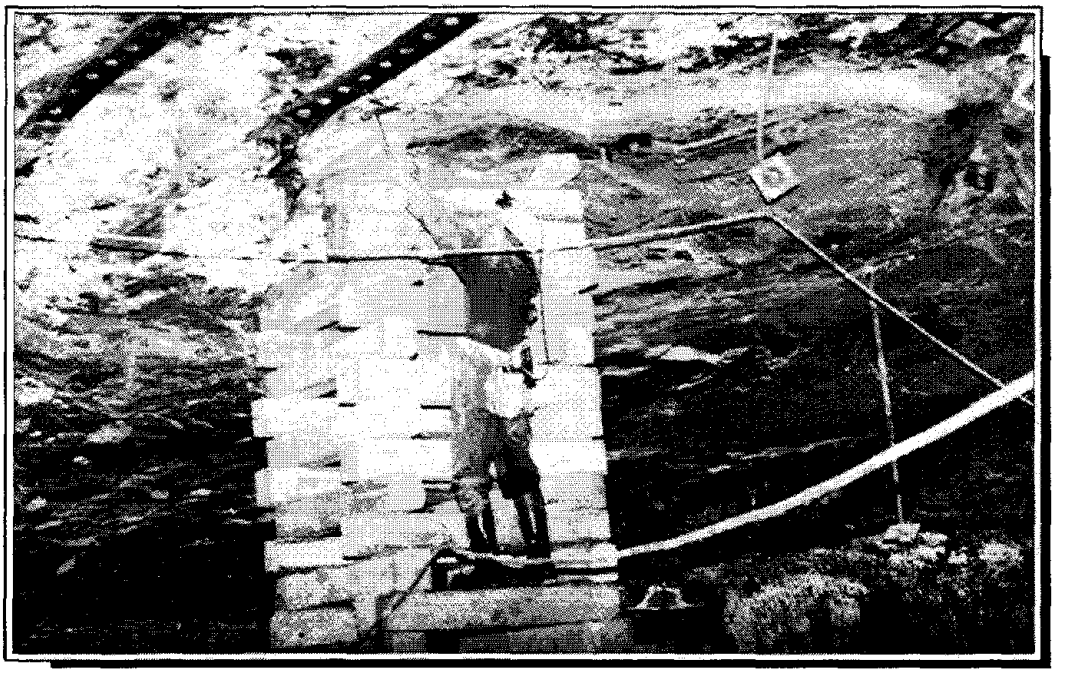
A Personal Computer Program and Spreadsheet for Calculating the Coal Mine Roof Rating (CMRR)

By Jennifer Riefenberg and William J. Wuest



United States Department of the Interior

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Cover photograph: Collection of data for CMRR from roof fall exposure in underground coal mine. (Photo: Christopher Mark, Pittsburgh Research Center, U.S. Bureau of Mines)

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cm	centimeter	kb	kilobyte
ft	foot	m	meter
h	hour	Mb	megabyte
in	inch	mm	millimeter

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A PERSONAL COMPUTER PROGRAM AND SPREADSHEET FOR CALCULATING THE COAL MINE ROOF RATING (CMRR)

By Jennifer Riefenberg[1] and William J. Wuest[2]

ABSTRACT

A family of personal computer programs that calculate the Coal Mine Roof Rating (CMRR) has been developed by the U.S. Bureau of Mines. The CMRR rock mass classification system provides a link between the qualitative geologists' description of coal mine roof and the quantitive mine engineers' needs for mine design, roof support selection, and hazard detection.

The program CMRR is a user-friendly, interactive program into which raw field data are input. A CMRR is calculated and output along with two graphic displays. The first graphic display is a plan view map with the CMRR's displayed on a color-coded scale. The second display shows a stratigraphic section of the bolted roof interval and its resultant CMRR. In addition, a Lotus 1-2-3 worksheet, computer file BOM-CMRR.WK3, has been developed for easy storage of field data. The worksheet includes four macros that automatically calculate CMRR's, store field test data in a database format, and print a two-page report of the field data and CMRR parameters. Production of summary reports for analysis of site-specific information are readily generated using Lotus 1-2-3 software. These programs help to facilitate the engineer in utilizing the CMRR in ground control studies.

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INTRODUCTION

U.S. Bureau of Mines (USBM) researchers are actively involved in investigating coal measure roof and floor strata properties for use in preventing underground coal mine hazards. By quantifying roof quality as a numeric rating, descriptive geologic information may now be readily incorporated by the mine engineer into ground control analyses. USBM researchers recently developed a practical roof rock rating system known as the Coal Mine Roof Rating (CMRR), which enables an engineer to efficiently affix a strength value between 0 (*weak*) and 100 (*strong*) to a bolted roof (Molinda and Mark, 1993 and 1994). The CMRR has been successfully incorporated into the USBM-developed Analysis of Longwall Pillar Stability (ALPS) pillar design tool as recent research has shown that the selection of a stability factor should be based upon an evaluation of roof quality (Mark and Chase, 1993). The USBM is also in the process of developing a hazard mapping system capable of integrating various geotechnical information for locating potential hazard zones in an underground coal mine. Part of this hazard mapping system will incorporate a roof rock rating map delineating areas of *weak, moderate,* and/or *strong* rock using the CMRR. Other uses of the CMRR are concerned with intersection span design, system support design, and coal pillar and entry design.

A computer program[3] has been developed that enables a user to compute the CMRR from user-input raw field data. Currently, a series of hand calculations with attached lookup tables are required to compute the CMRR. The computer programs and spreadsheets have been developed to facilitate the process of calculating the CMRR by hand. The c-language programs were developed for all levels of computer users and reside in the public domain. These c programs automatically generate two graphics displays as well as text data files containing the CMRR's. These text data output files allow a user to transfer the field data and ratings into a Geographic Information System (GIS) or many other computer-aided design (CAD) type packages for further analysis. Lotus 1-2-3 software is a readily available package that allows for the manipulation and storage of tabular data. Thus, a spreadsheet was developed specifically for those users who prefer spreadsheet programs and who may not require the graphic output displayed using the c programs. Lotus 1-2-3 software also is a high-powered product for conveniently generating reports from the database of worksheets that is created by the user.

BACKGROUND

Rock mass classification systems came about as the need for understanding rock behavior in civil engineering tunneling projects grew. The earliest design scheme using rock mass characterization was reported in 1946 by Terzaghi and was specific to tunneling with steel supports. In this report, Terzaghi classified rock types based on jointing, squeezing, blockiness of the rock, etc., and developed a rock load computation to estimate the level of support required. The natural progression of science and technology has led rock mass classification systems into the underground mining regime.

As reported by Hoek and Brown (1980), two significant works in rock mass characterization were reported in 1950 by Stini and in 1958 by Lauffer. Although the actual reports by Stini and Lauffer are not widely recognized nor readily available in the United States, both of these researchers had an influence on virtually all classification schemes later developed. Stini recognized the significant effects of structural defects on a rock mass, while Lauffer recognized the importance of the *standup time* and *active span* effects. The first widely used rock mass classification system was developed in 1963 by Deere and Deere [see Kirkaldie (1987)] and formalized as the rock quality designation (RQD) in 1967. By using the RQD as one parameter in describing rock structure, two classification systems were developed, independently, by Bieniawski (1979), and Barton and others (1974). These classification systems are known as the Rock Mass Rating (RMR), or Geomechanics Classification system, and Norwegian Geotechnical Institute (NGI) systems, respectively. Both the RMR and the NGI systems have become the standards for use in virtually all underground structures. The Unified Rock Classification System (URCS) was developed in 1984 by Williamson and is also a widely used system. For a detailed history of classification systems, see Hoek and Brown (1980), Kirkaldie (1987), and Bieniawski (1989). There are a number of studies that have attempted to characterize coal strata, although with limited success. Most of these are outlined in a report on the CMRR by Molinda and Mark (1994). Recently, Kalamaras and Bieniawski (1993) investigated rating coal pillars using

[3]The program is available on an 8.9-cm (3.5-in) or 13.3-cm (5.25-in) floppy disk. To obtain a copy, send requests to the Denver Research Center, U.S. Bureau of Mines, P.O. Box 25086, Denver Federal Center, Denver, CO 80225. Please reference this report.

DATE_____MINE_____LOCATION_____PAGE_____OF_____ CMRR_____

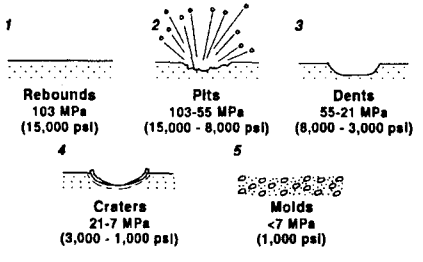
TYPE OF EXPOSURE_____ NAME_____

UNIT

Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity
3					
	CONTACT				
2					
	CONTACT				
1					

UNIT DISCONTINUITIES

Disco. I.D.	Description	Cohesion	Rough-ness	Spacing	Persistence Lateral/Vert	Orientation Strike	Orientation Dip
A.							
B.							
C.							
A.							
B.							
C.							
A.							
B.							
C.							



	Strength	Moisture Sensitivity
1	Rebounds	Not Sensitive
2	Pits	Slightly Sensitive
3	Dents	Moderately Sensitive
4	Craters	Severely Sensitive
5	Molds	

	Cohesion	Rough-ness	Spacing	Persistence Lateral/Vert	Orientation Strike	Orientation Dip
1	Strong (>7)**	Jagged	>1.8 m (6 ft)	0-0.9 m (0-3 ft)	N	Horiz.
2	Moderate (4-7)	Wavy	0.6-1.8 m (2-6 ft)	0 .9-3 m (3-10 ft)	NE	Subhoriz.
3	Weak (1-3)	Planar	20-60 cm (8-24 in)	3-9 m (10-30 ft)	E	45°
4	Slicken-sided (0)		6-20 cm (2.5-8 in)	>9 m (30 ft)	SE	Subvert.
5			<6 cm (2.5 in)		S	Vert.

Ground Water (inflow/10 m (33 ft) of entry length) (Circle)

l/min (g/min)

Dry 0 — 1 Heavy Drip 10-50 (2.7-12.2) — 4

Damp 0-5 (0-1.3) — 2 Flowing >50 (13.2) — 5

Light Drip 5-10 (1.3-2.7) — 3

Describe condition in vicinity of fall (circle one)

1. Good 3. Heavy

2. Scaly 4. Failed

** Hammer blows necessary to split bedding with 9 cm (3.5 in) chisel

COMMENTS: (Roof Support, etc.)

Figure 1.—Sample field data worksheet for CMRR system.

COAL MINE ROOF RATING (CMRR) FIELD DATA SHEET DIRECTIONS

1. *Apply classification to entire roof exposure, (use several sheets if necessary).*

2. *Use criteria below each category to classify that category.*

3. *Begin with a description of each unit and use "strength", "moisture sensitivity", and "persistence" to describe each bed.*

4. *Then describe each discontnuity (bedding plane, slickenside, inclusion, cross bed, etc.) within the bed by the criteria provided below each column.*

5. *Three rows are provided for up to three discontinuities.*

Unit *- Any distinct rock bed (> 6 in. thick) which forms a structural member in the roof.*

Discontinuity *- Any surface which interrupts the lateral or vertical continuity of a unit or sequence of units (bedding planes, slickensides, shears, joints).*

Contact *- The interface between roof strata, which may be described as sharp or gradational.*

Strength *- The compressive strength of the intact rock within a as indicated by a hammer impact test.*

Moisture sensitivity *- Immerse sample in water for 24 hours to determine its degree of disintegration.*

Spacing *- Indicate how closely spaced are the discontinuities.*

Cohesion *- An estimation of the ability of a surface (bedding plane, discontinuity) to resist separation or shear estimated by the number of blows necessary to split the discontinuity with a 3-1/2" chisel.*

Roughness *- Describe the shape of the discontinuity surface as "jagged, wavy, or planar".*

Orientation *- Estimate the orientation of the discontinuity relative to the heading orientation (quadrants). Estimate the dip on the discontinuity.*

Figure 1.—Sample field data worksheet for CMRR system—Continued.

a modified RMR along with numerical modeling. For a concise overview of the most widely used classification schemes pertaining to underground mining, see Afrouz (1992).

Regardless of the engineering field, rock mass classification techniques usually involve laboratory analysis and/or drill core analysis of the rock, which is often a time-consuming task. Because of the impracticality of utilizing existing classification systems for extensive or large-scale sampling, the USBM recognized a need for developing a practical rock mass classification system geared specifically toward coal mine roof rather than for a generic rock mass. Four main contributions have been included in the resulting research, namely the development of the CMRR: (1) It is specifically designed for bedded coal measure rocks, focusing on discontinuity properties of these rocks, (2) it concentrates on the bolted interval and its ability to form a stable mine structure from the units within the interval, (3) it is applicable to all U.S. coal seams, thus providing a standard for comparison with other coal mine roof rocks, and (4) it provides a methodology to guide data collection.

COAL MINE ROOF RATING (CMRR) TECHNIQUE

PHILOSOPHY

The CMRR is an empirically driven technique, based on data from 76 underground coal mines (Molinda and Mark, 1994). The CMRR is a practical system for rating a coal mine roof, relying on simple field measurements. The CMRR is a strength or competence rating on a scale from 0 to 100, with values less than 45 considered poor or *weak*, values between 45 and 65 considered *moderate*, and values greater than 65 considered *strong*. Common sense must be used when utilizing the CMRR as a hazard indicator. For example, a *weak* rating is usually accepted as a potential problem area; however, a *strong* rating does not necessarily mean the area is safe.

Like other classification systems, the CMRR is based on the premise that structural competence of the roof is determined primarily by discontinuities that weaken the rock fabric. The CMRR was designed to focus on evaluating the geotechnical, rather than the geologic, characteristics of coal mine roof. Often the geotechnical and geologic characteristics correspond, but the emphasis is on structurally weak or strong units as opposed to geologic divisions. Emphasis is shifted from the cumbersome lithologic description to those characteristics that weaken bedded coal measure rocks—namely, bedding planes, slickensides, joints, and laminations. The CMRR evaluates the properties of discontinuities found in a unit and how these properties combine to weaken the roof. The CMRR provides guidelines for (1) the efficient collection of data relevant to roof competence, and (2) evaluation of the rock mass properties that affect roof competence.

Spacing and persistence of the discontinuities, cohesion of the discontinuities, groundwater effects, as well as rock strength and other properties are all typically considered in most rock mass classification schemes and the CMRR is no exception to this. A major difference between existing rock mass classification techniques and the CMRR classification scheme is that the CMRR considers individual coal measure rock units within the bolted interval in underground coal mines. Experience has indicated that the bolted roof interval has a significant impact on ground control.

The CMRR uses the bolted roof interval as the source of input data. Sources of data for the CMRR are exposures such as roof falls and overcasts. This roof interval is then subdivided into units, where a unit may be defined as rock strata greater than 150 mm (6 in) in thickness exhibiting distinctive strength properties. A single unit will be characterized by common discontinuities through it as well as similar strengths. In other words, an individual unit can be analyzed as needed for the field data worksheet (figure 1). When corehole data or even unit identification from roof bolting observation holes are used, jointing and other larger scale discontinuities cannot readily be delineated. The CMRR can still be used if prior discontinuity information is known for the individual units in the exposure and is assumed relatively constant throughout an area.

PROCEDURE

Figure 1 shows a field data worksheet for the CMRR system. This table is completed by the field observer for each roof exposure. By using the worksheet and calculation sheets, a CMRR can be computed using a series of "lookup" tables and simple weighted averages of individual unit ratings. [See Molinda and Mark (1994) for a complete discussion on the CMRR procedure.] It is highly recommended that one become familiar with the hand calculations to better understand the various influences of the rating criteria and to become proficient with using the technique.

The process of hand calculating the CMRR, although quite easily done, can be a tedious task. With this in mind, a personal computer program was developed for the calculation of the CMRR. With this program (or series of programs), one need only input (interactively, if desired) field data worksheet information from which the program

computes the CMRR. Output is a screen listing of the rating(s), text file storage of the rating(s), and two graphics displays including the rating(s). A Lotus 1-2-3 spreadsheet, discussed in the section "Using Lotus 1-2-3 Worksheet for Computing CMRR," was also developed for the storage of field data, calculation of the CMRR, and generation of site-specific roof control study reports.

CMRR FAMILY OF PROGRAMS

This section discusses each program in the CMRR family. The specific function of each program is stated. Figure 2 presents a schematic flow diagram of the programs.

CMRR

The CMRR program contains the complete processing sequence from data input through graphic display and text file output. With the program CMRR, the user can input raw field data, interactively, from which a rating is computed, stored, and displayed.

Clasfile

The Clasfile program is an interactive program for the user to input and store the raw field data into a text file. As indicated, the user simply inputs requested information from the completed field data sheets (figure 1) in an interactive mode. The field data are then stored in a user-specified text file for processing and/or storage. This text file can then be used as input into the Classify program, described below.

Classify

The Classify program is useful when a text data file exists. The file is created using either the Clasfile program or any text editor, and a rating number is all that is desired. Thus, input into the Classify program are the field data formatted in a text file, and the output is a screen listing as well as a two text output files containing the rating(s).

Rockplot

The Rockplot program is a graphic display program that plots the output ratings onto a plan view map using user-specified coordinates. Program input is simply a text file containing x and y coordinates of the rating along with the rating itself. This input file can be created using either the Classify program, the CMRR program, or a text editor manually. Output from the program is a screen display of the ratings, categorized within the *weak*, *moderate*, or *strong* ranges. This program is useful for delineating areas of concentrated weak zones, etc.

Rockmplt

The Rockmplt program is identical to the Rockplot program except that a mine map in plan view is also shown. To use the Rockmplt program, the user must create a text file containing the mine map features. This additional file is then read and a plot generated, superimposing the two data sets.

Stratplt

The Stratplt program is a graphic display program that plots the output ratings with their corresponding stratigraphic column for the bolted interval. Input is, again, a text file of the output ratings (created using Classify or CMRR) along with the input file for the ratings computation (created using Clasfile or CMRR). Output from the program is a screen display showing the stratigraphic column with unit names, the x and y locations of the sample, the number of discontinuities within each unit, and the sample rating.

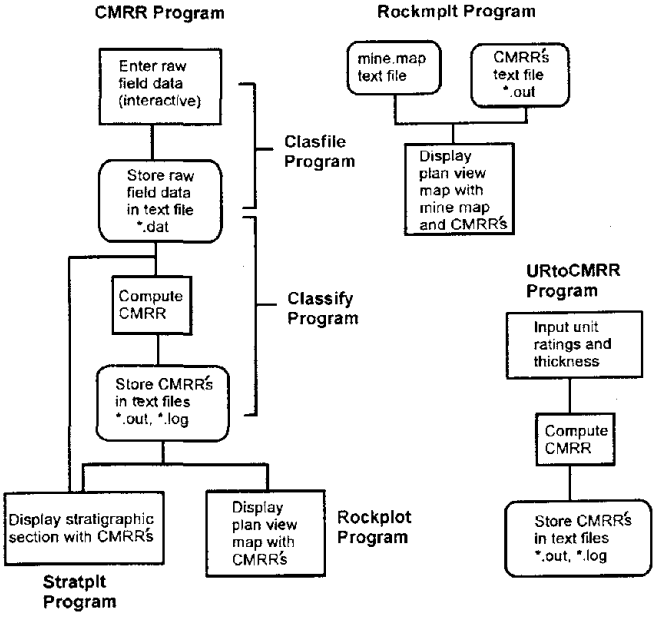


Figure 2.—Schematic flow diagram of CMRR family of programs.

URtoCMRR

The URtoCMRR program is a program for computing the CMRR's, given unit ratings and the thickness of each unit for a given sample. Input is interactive with output being, again, a text file containing the ratings for each sample input. This program is very useful when a unit has been examined in the field and is found to have a consistent rating throughout a mine, but has varying thickness and/or occurrence. This program is very useful for parametric studies.

The next sections will describe in greater detail the file structures as well as sample sessions for select programs. The program installation instructions are given in appendix A.

SAMPLE SESSION WITH PROGRAM CMRR

The CMRR and Clasfile programs both require input from the field data sheets. Information necessary for the computation of the CMRR includes unit thickness, unit strength, moisture sensitivity, persistence, and descriptions of unit discontinuities, including spacing, cohesion, roughness, and persistence, as shown in figure 1. Input of these data into the CMRR or Clasfile programs is done interactively. To execute either program, the user only needs to type **CMRR**[4] or **Clasfile** at the *c:>*[5] prompt and press <Enter>.[6] A sample session of the CMRR program is shown below. (In this example, each new screen display is simulated with a solid line.)

*c:>***CMRR** <Enter>

What is the name of the file (for the field data) that you would like to create? (no extension needed) **test**

Do you prefer units in meters or feet? (m/f) **f**

What are the x and y coordinates for sample 1? (x,y) **15, 30**

What is the sample ID for sample 1? Note: There can be no spaces in the ID name, but underscores are okay, e.g., xc32_x1.
ID: **test1**

What is the location name for the sample? Note: There can be no spaces in the sample location although underscores are okay.
Location: **Utah**

For sample 1, how many units do you have to input? **2**

What is the length of the bolted interval for sample test1? (ft) **5**

How many planes of significant weakness are there in the sample? **2**

There are 2 units in this sample, 2 plane(s) of significant weakness, and the bolted interval is 5.00 ft. Is this correct? (y/n) **y**

How thick is unit 1? (ft) **2.3**

Describe (name) the unit. (<15 characters) Note: There can be no blank spaces in the name, but underscores are okay, e.g., top_coal. Enter the description here: **shale**

What is the response of the rock when impacted with the hammer?

1: rebounds	2: pits	3: dents
4: craters	5: molds	

Please input the number for unit strength that applies: **3**

What is the moisture sensitivity of the unit (using either a preimmersion breakability (visual) test or a 24-h water immersion test)?

1: not sensitive	2: slightly sensitive
3: moderately sensitive	4: severely sensitive

Please input the number for this unit: **2**

How many discontinuities are there in unit 1? **2**

Unit 1, described as shale, is 2.3 ft thick. It has a strength of 3 and moisture sensitivity of 2. In addition, there are 2 discontinuities in the shale.
Is this correct? (y/n) **y**

Describe (name) discontinuity 1. (<15 characters) Note: There can be no blank spaces in the name, but underscores are okay, e.g., joint_set. Enter the description here: **joints**

---

[4]Boldface characters are typed by the user.
[5]Prompts displayed on the screen are italicized.
[6]Function keys, indicated by < >, are pressed by the user.

Determine this discontinuity's cohesion, where the numbers in parentheses are the number of blows necessary to split bedding with a 9-cm (3-1/2-in) chisel.
1: strong (>7) 2: moderate (4 - 7)
3: weak (1 - 3) 4: slickensided (0)
Please input the number for this unit: **3**

What is the roughness of the discontinuity, joints?
1: jagged 2: wavy 3: planar
Please input the number for this unit: **3**

Determine the spacing of the discontinuity, joints.
1: >1.8 m (>6 ft) 2: 0.6 - 1.8 m (2 - 6 ft)
3: 0.2 - 0.6 m (8 - 24 in) 4: 6 - 24 cm (2.4 - 8 in)
5: <6 cm (<2.5 in)
Please input the corresponding number for this unit: **2**

What is the persistence of the discontinuity?
1: 0 - 0.9 m (0 - 3 ft) 2: 0.9 - 3 m (3 - 10 ft)
3: 3 - 9 m (10 - 30 ft) 4: >9 m (>30 ft)
Please input the number for this unit: **3**

Discontinuity 1 is described as joints. It has a roughness of 3.0, cohesion of 3.0, spacing of 2.0, and persistence of 3.0.
Is this correct? (y/n) **y**

Describe (name) discontinuity 2. (<15 characters) Note: There can be no blank spaces in the name, but underscores are okay, e.g., joint_set. Enter the description here: **bedding**

Determine this discontinuity's cohesion, where the numbers in parentheses are the number of blows necessary to split bedding with a 9-cm (3-1/2-in) chisel.
1: strong (>7) 2: moderate (4 - 7)
3: weak (1 - 3) 4: slickensided (0)
Please input the number for this unit: **2**

What is the roughness of the discontinuity, bedding?
1: jagged 2: wavy 3: planar
Please input the number for this unit: **2.5**

Determine the spacing of the discontinuity, bedding.
1: >1.8 m (>6 ft) 2: 0.6 - 1.8 m (2 - 6 ft)
3: 0.2 - 0.6 m (8 - 24 in) 4: 6 - 24 cm (2.4 - 8 in)
5: <6 cm (<2.5 in)
Please input the corresponding number for this unit: **2**

What is the persistence of the discontinuity?
1: 0 - 0.9 m (0 - 3 ft) 2: 0.9 - 3 m (3 - 10 ft)
3: 3 - 9 m (10 - 30 ft) 4: >9 m (>30 ft)
Please input the number for this unit: **4**

Discontinuity 2 is described as bedding. It has a cohesion of 2.0, roughness of 2.5, spacing of 2.0, and persistence of 4.0.
Is this correct? (y/n) **y**

__ (Note: Input begins for second unit in this sample.)__

How thick is unit 2? (ft) **3.1**

Describe (name) the unit. (<15 characters) Note: There can be no blank spaces in the name, but underscores are okay, e.g., top_coal. Enter the description here: **sandstone**

What is the response of the rock when impacted with the hammer?
1: rebounds 2: pits 3: dents
4: craters 5: molds
Please input the number for unit strength that applies: **2**

What is the moisture sensitivity of the unit (using either a preimmersion breakability (visual) test or a 24-h water immersion test)?
1: not sensitive 2: slightly sensitive
3: moderately sensitive 4: severely sensitive
Please input the number for this unit: **1**

How many discontinuities are there in unit 1? **0**

Unit 2 , described as sandstone, is 3.1 ft thick. It has a strength of 2 and a moisture sensitivity of 1. In addition, there are 0 discontinuities in the sandstone.
Is this correct? (y/n) **y**

What is the cohesion of the unit, sandstone, where the numbers in parentheses are the number of blows necessary to split bedding with a 9-cm (3-1/2-in) chisel?
1: strong (>7) 2: moderate (4 - 7)
3: weak (1 - 3) 4: slickensided (0)
Please input the strength number for this unit: **1**

What is the roughness of the unit?
1: jagged 2: wavy 3: planar
Please input the number for the sandstone: **1.5**

What are the ground water conditions of the sample?
1: dry 2: damp 3: light drip
4: heavy drip 5: flowing
Please enter the appropriate number: **2**

Are the upper beds approximately
1: equal in strength to the sample?
2: weaker in strength to the sample?
Please enter the appropriate number: **1**

This sample has ground water of 2 and the upper beds surcharge are of value 1.
Is this correct? (y/n) **y**

Do you have more data to input? (y/n) **n**

****

Input complete. Data are stored in a file called test.dat.

****

Press any key to continue.

For sample 1, the CMRR is 78.

Press any key to continue.

The data file has been read and CMRR's computed. Your output is listed in the file named test.out.

Press any key to continue with the plotting of the rating.

_ (Note: The following will calibrate your map limits.)_

What is the minimum x-axis value? **0**

What is the minimum y-axis value? **0**

What is the maximum x-axis value? **50**

What is the maximum y-axis value? **50**

The sample screen outputs from the CMRR program are illustrated in figures 3 and 4. Figure 3 shows the plan view map display, while figure 4 shows the stratigraphic column display.

PROGRAM FILES—INPUT AND OUTPUT

The program Clasfile is exactly the same as the data input steps of the CMRR program. The Classify, Rockplot, Rockmplt, and Stratplt programs are very similar to portions of the CMRR program.

Programs Clasfile and CMRR

Input into the Clasfile and CMRR programs is interactive, allowing the user to enter data from the field data sheets, which is then saved to a text file. Input files containing the raw field data are automatically named with an *.dat extension. Text files created by a text editor should be named with an *.dat extension and follow the format given as an example below. Also, for those using a text editor, there should also be at least one blank space in line 1 as the first entry in the file. Spacing between entries on a line is not critical. At least one blank space must separate parameters. A sample input file for raw field data is shown below:

File data	Line
1 10.00 f 3 test1 Utah	1
shale 13.0 2 2 1	2
laminations 3.0 1.0 3.0 4.0	3
4 1 45.000000 37.000000	4
3 8.0 f 2 test2 Utah	5
shale 3.0 3 2 2	6
bedding 3.0 2.0 2.0 4.0	7
kettle_bottom 1.0 3.0 1.0 2.0	8
sandstone 3.0 2 1 0	9
1.5 1.5	10
shaley_clay 3.0 3 2 1	11
laminations 3.0 2.0 2.0 4.0	12
2 1 165.000000 150.000000	13

Line 1 of the file contains the number of units for the sample (1), bolted interval length (10.00), units of measure (f = feet), number of weak planes (3), sample identification (ID) (test1), and sample location name (Utah). Line 2 contains the unit name (shale), unit thickness (13.0), unit strength (2), moisture sensitivity (2), and

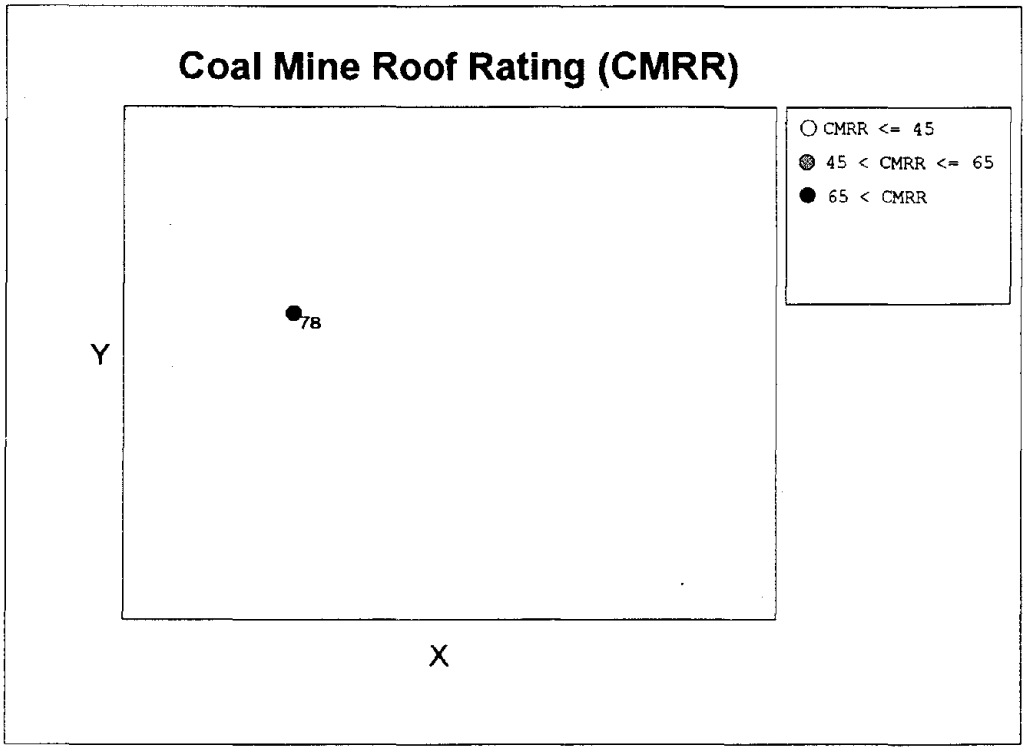


Figure 3.—Plan view map display of sample screen output from CMRR program using example from sample session.

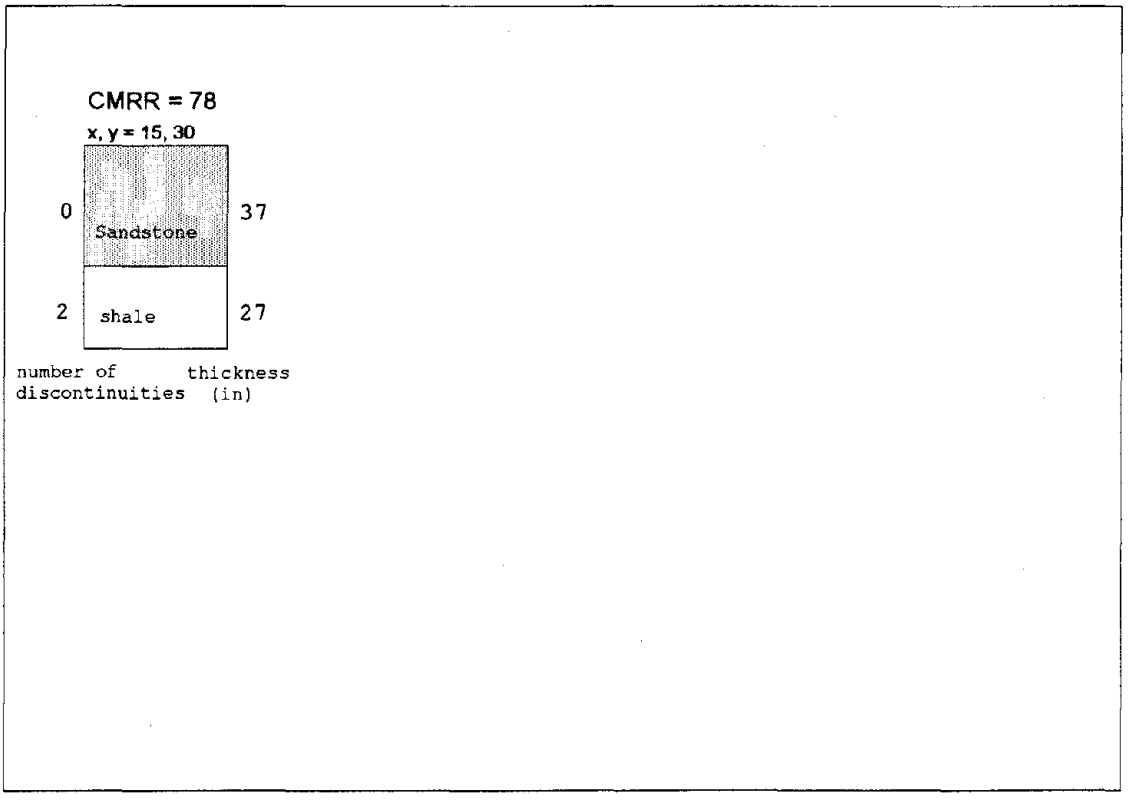


Figure 4.—Stratigraphic column display of sample screen output from CMRR program using example from sample session.

number of discontinuities for the unit (1). For the one discontinuity in this example, line 3 in the file contains the discontinuity name, cohesion, roughness, spacing, and persistence. Line 4 then contains the groundwater index, the upper beds surcharge index, and the x and y coordinates of the sample. Lines 5 through 13 then contain the input data for a second sample. Line 5 contains the same information for the second sample as line 1. Line 6, similarly, contains the first unit name, unit thickness, unit strength, moisture sensitivity, and number of discontinuities for the unit. Lines 7 and 8 contain the discontinuity names, spacing, cohesion, roughness, and persistences. Line 9 then gives the description for the second unit in the sample (with no discontinuities), and line 10 gives the cohesion and roughness for the intact unit. Lines 11 and 12 give the description for the third, and final, unit in the sample. Similar to line 4, line 13 contains the groundwater index, the upper beds strength index, and the x and y coordinates of the sample. There is no limitation to the number of samples in a single file other than machine capacity.

Program Classify (CMRR and Stratplt)

Input into the Classify program is a text file containing the raw field data, such as that created by either the Clasfile or CMRR programs. The Classify program simply computes the CMRR and outputs the CMRR's to a text file as well as the computer screen. One text file containing the output CMRR's has an *.out extension on the file name. A sample output file (*.out) from Classify (or CMRR) is listed in table 1. Line 1 of the table contains the x and y coordinates for the sample, the corresponding CMRR (here a value of 52), the number of units in this sample, and the corresponding unit ratings. Similarly for line 2, corresponding to a second sample with a resultant rating of 75 and three unit ratings of 57, 88, and 57, respectively. This file serves as an input file for the Rockplot, Rockmplt, and Stratplt programs. The second text output file from the Classify or CMRR programs is automatically named with an *.log extension. This output file creates a master database file listing the sample ID, the location of the sample, and the resultant CMRR. Table 2 shows an example file for the *.log text file output.

Table 1.—Example file format for *.out file created by program CMRR, Classify, or URtoCMRR

Line	Location		CMRR	Number of units	Unit rating		
	x	y			Unit 1	Unit 2	Unit 3
1 . . .	45	37	52	1	63	NAp	NAp
2 . . .	165	150	75	3	57	88	57

NAp Not applicable.

Table 2.—Example file format for output text file with *.log extension created by program CMRR, Classify, or URtoCMRR

Line	Sample ID	Location	CMRR
1	test1	Utah . . .	52
2	test2	Utah . . .	75

ID Identification.

Program Rockplot

To run the Rockplot program, input the file name containing the rating output (with an *.out file extension) at the user prompt. An example *.out file is shown in table 1.

Program Rockmplt

To run the Rockmplt program, a second file is necessary, in addition to the rating output file. This second file is a text file containing the plan view mine map as a series of rectangles. The format of this file is shown below and is an example mine data file (named mine.dat) corresponding to the output shown in figure 5, along with rating data from the sample file included on the disk[7] (USBMtest.*).

Example mine.map file	Line
0.0, 0.0, 250.0, 250.0	1
0, 0, 30, 250	2
50, 10, 80, 90	3
50, 110, 80, 190	4
50, 210, 80, 250	5
100, 0, 180, 40	6
100, 60, 180, 140	7
100, 160, 180, 240	8
200, 0, 250, 250	9

Line 1 of this file contains the minimum and maximum x and y coordinates, respectively. In this example, the minimum x and y coordinates are both 0.0 and the maximum, both 250.0. The next eight lines (2 through 9) are rectangle coordinates (opposite corner to opposite corner) corresponding to the mine pillars. For example, from line 2, the rectangle lower left corner has x and y coordinates (0, 0) and the upper right corner has x and y coordinates (30, 250). This file can be as detailed or as general as required. A scale that is too large, resulting in a highly detailed map, may lose its practical value when the ratings are viewed.

[7]See footnote 3.

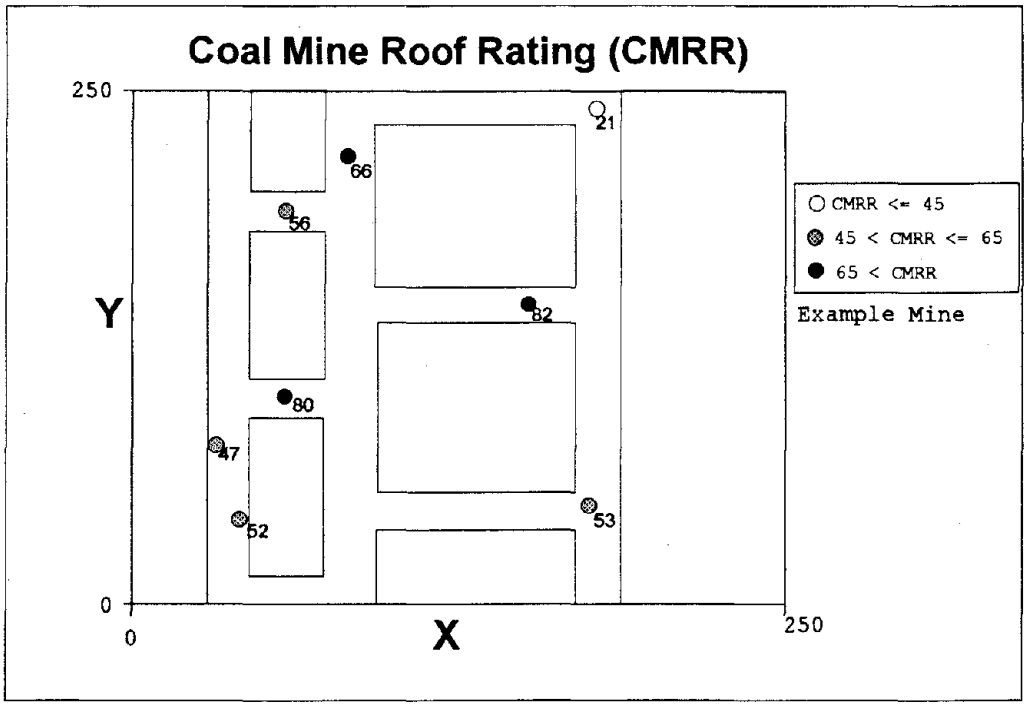


Figure 5.—Sample screen display from program Rockmplt. Values are color coded for CMRR's in *weak, moderate,* or *strong* ranges. Data are from example file USBMtest.out on disk.

Program Stratplt

The final graphing program is the program Stratplt. Both the *.dat and the *.out files are required to run the Stratplt program. These two files have the same name with different extensions. Figure 6 shows a second example of output from the Stratplt program (see also figure 4). Ten stratigraphic columns, corresponding to 10 samples, can be shown at once on the same screen, with additional samples shown on a series of successive screens.

Program URtoCMRR

An additional program that may prove to be useful is the program URtoCMRR. This program allows a user to interactively input unit ratings and their corresponding thicknesses and, from these data, compute a CMRR. Output is, again, a text file containing the ratings and their corresponding coordinates (*.out) and a text file containing CMRR and location information for a master database file (*.log). Only the Rockplot and Rockmplt programs can be used with ratings computed using the program URtoCMRR since there is no raw field data input file (*.dat), as required for the Stratplt program.

SAMPLE SESSION WITH PROGRAM URtoCMRR

A sample session of the URtoCMRR program is demonstrated below:

c:>**URtoCMRR** <Enter>

What is the name of the file (for the field data) that you would like to create? (no extension needed) **test1**

Do you prefer units in meters or feet? (m/f) **m**

What are the x and y coordinates for sample 1? (x,y) **10, 50**

What is the sample ID for sample 1? Note: There can be no spaces in the ID name, but underscores are okay, e.g., xc32_x1.
ID: **example1**

What is the location name for the sample? Note: There can be no spaces in the sample location, but underscores are okay.
Location: **Utah**

For sample 1, how many units do you have to input? **2**

What is the length of the bolted interval for sample, example1? **2**

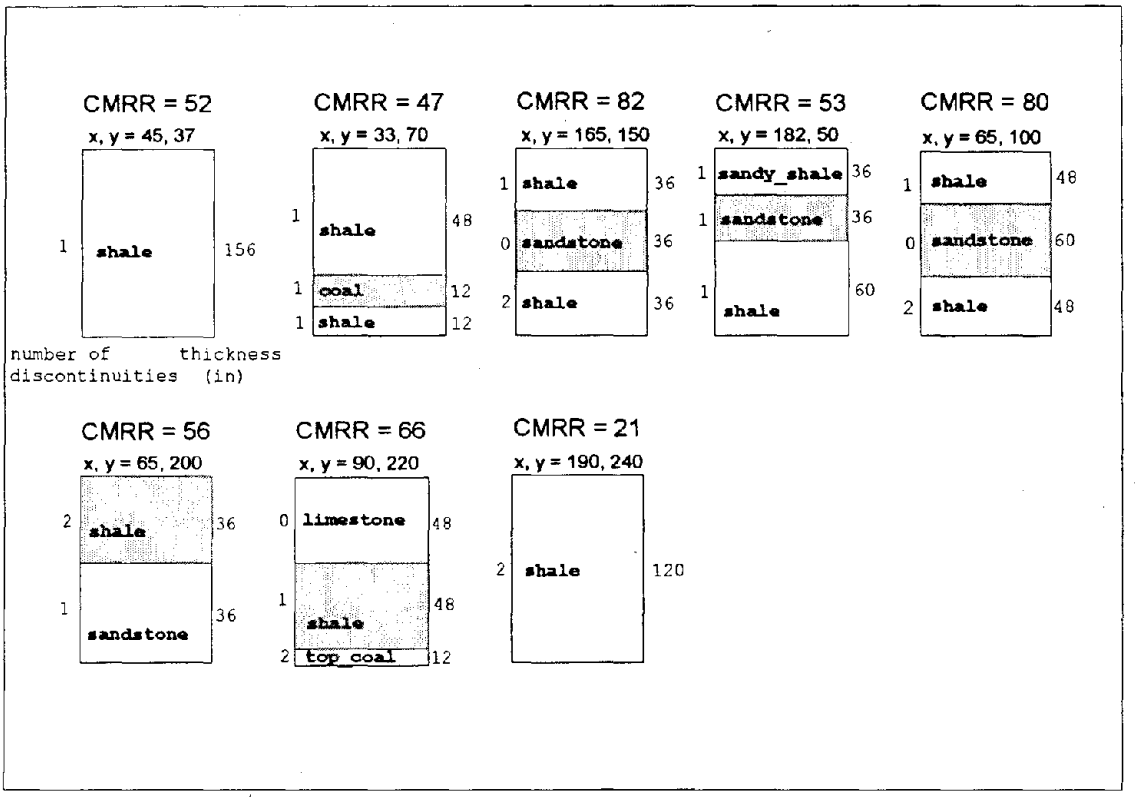


Figure 6.—Sample screen display from program Stratplt. Up to 10 stratigraphic sections may be displayed on 1 screen. Data are from example file USBMtest.out on disk.

How many planes of significant weakness are there in the sample? **1**

There are 2 units in this sample, 1 plane(s) of significant weakness, and the bolted interval length for this is 2.0 m. Is this correct? (y/n) **y**

How thick is unit 1 (in/m)? **0.9**

Describe (name) the unit. (<15 characters) Note: There can be no blank spaces in the name, but underscores are okay, e.g., top_coal. Enter the description here: **shale**

Enter the unit rating (UR) for the shale: **67**

The shale is 0.9 m thick and has a unit rating of 67. Is this correct? (y/n) **y**

How thick is unit 2 (in/m)? **1.2**

Describe (name) the unit. (<15 characters) Note: There can be no blank spaces in the name, but underscores are okay, e.g., top_coal. Enter the description here: **mudstone**

Enter the unit rating (UR) for the mudstone: **31**

The mudstone is 1.2 m thick and has a unit rating of 31. Is this correct? (y/n) **y**

What are the groundwater conditions of the sample?
1: dry 2: damp 3: light drip
4: heavy drip 5: flowing
Please enter the appropriate number: **2**

Are the upper beds approximately
1: equal in strength to the sample?
2: weaker in strength to the sample?
Please enter the appropriate number: **2**

This sample has groundwater of 2 and the upper beds surcharge are of value 2.
Is this correct? (y/n) **y**

For sample 1, the CMRR is 38.

Press any key to continue.

Do you have more data to input? (y/n) **n**

The CMRR's have been computed.
Your output is listed in the file named test1.out.

DISCUSSION OF CMRR PROGRAMS FOR FIELD DATA ANALYSIS

The next logical step, once the user has become familiar with the CMRR family of programs, is to input, store, and analyze the data. For a given data set (e.g., a mining section where a set of field worksheets have been completed and/or a reasonable geologic map of the immediate roof has been documented so that unit ratings for the roof units can be computed), one may enter the complete data set into a single file for processing through the family of programs. These data files (input: raw field data, and output: resultant ratings) are in a convenient format for permanent storage. Once the data have been entered and the CMRR's computed using the CMRR (or Clasfile and Classify) program(s), the output text file may be read directly into a number of software packages for plotting and analysis. For example, the programs Surfer and Grapher can read directly the output file from CMRR. Surfer is a three-dimensional plotting package and Grapher is a two-dimensional graphing-drawing package. With Surfer, one may produce contour plots or three-dimensional mesh diagrams of the CMRR data. Figure 7 is an example contour plot of CMRR's computed using the CMRR program and plotted with Surfer. Figure 8 shows a three-dimensional mesh diagram using the same example as presented in figure 7, again with Surfer. Data for these plots are from the example file (USBMtest.out), which is included on the floppy disk.[8] The plots were created in a few minutes from raw data entry into CMRR to importation into and plot output from Surfer. Data from the programs can also be read directly into high-powered drawing-mapping software packages such as AutoCAD. Many additional graphing packages

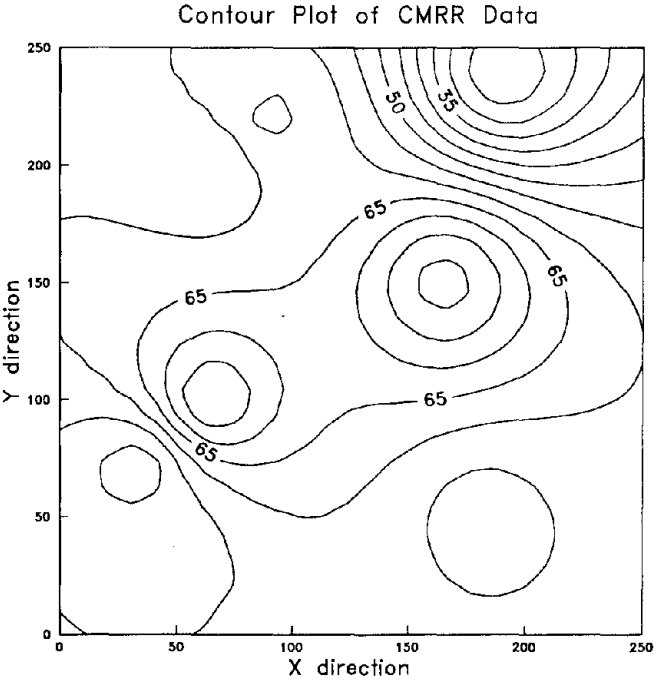


Figure 7.—Contour map of CMRR data using program Surfer. Data are from example file USBMtest.out on disk. CMRR output file was read directly into Surfer.

[8]See footnote 3.

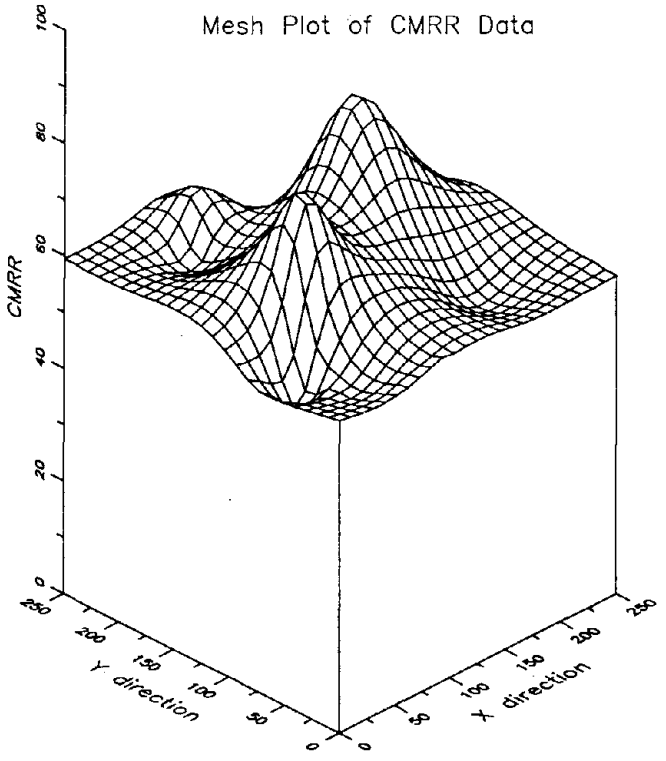


Figure 8.—Three-dimensional mesh plot of CMRR data using program Surfer. Data are from example file USBMtest.out on disk. CMRR output file was read directly into Surfer.

accept text [American Standard Code for Information Interchange (ASCII)] data files for input as well.

Many analysis packages for spatial data are becoming more widely used in the mining industry and, in particular, geostatistical analysis packages. Geostatistical (spatial) data analysis packages provide for the highly sophisticated analysis of data, specifically techniques for forecasting roof quality ahead of mining and/or in areas where few samples could be gathered. Output files from the CMRR family of programs containing CMRR's are a natural source of input into geostatistical analysis package, and because these files are in a text format, these data can be imported into packages such as the high-powered, public domain package GEO-EAS. In current USBM research, technology is being developed for direct importation of the CMRR data into the GEO-EAS program for analysis. CMRR data are readily imported into GIS's, such as ARC/INFO and the latest releases of AutoCAD, without further development. GIS technology is another powerful means of analyzing data by combining spatially connected information via layered mapping. CMRR data can then be overlain with local geology, surface topography, field measured and numerically modeled stresses, etc., to determine areas of potential hazard. GIS technology is another area of current USBM research for designing hazard maps related to ground control hazards in underground coal mines.

USING LOTUS 1-2-3 WORKSHEET FOR COMPUTING CMRR

The personal computer file BOM-CMRR.WK3 is a Lotus 1-2-3 worksheet program for use in conjunction with ground control studies that utilize the CMRR rock mass classification system. Mining information recorded on CMRR field data worksheets (figure 1) is entered into a prestructured computer worksheet to create a permanent electronic record of the field notes. After the field data are entered, with one keystroke the individual discontinuity ratings (IDR's), unit ratings (UR's), and CMRR's are automatically computed. Adjustments for multiple discontinuities, unit strength, moisture sensitivity, strong beds, bed contacts, groundwater, and surcharge are also computed and recorded to allow the user to analyze any CMRR parameter that may be significant to their specific problem. The program also has preconstructed macros to aid in data storage and report generation tasks.

When ground control studies are conducted, a large amount of data are collected (e.g., roof rock properties, artificial support types, geologic discontinuity information, and coal quality factors). After this information is entered into the worksheet program, Lotus 1-2-3 database commands can be used to generate summary reports on CMRR parameters and other pertinent mining information (figure 9). These reports can then be used to assist mine operation decisionmaking, prepare mine maps such as hazard prediction maps, and prepare other graphics such as gate road roof cross sections. Another use of the program is to perform parametric studies. Unit thickness, unit strength, moisture sensitivity, or any of the other variables that factor into the CMRR equation can be altered. Within seconds, new values for IDR's, UR's, and CMRR's are calculated and printed. In this manner, CMRR parameters can be evaluated for any number of possible mining scenarios to determine the sensitivity of these parameters to such influences as geologic discontinuities and groundwater.

Lotus 1-2-3 software is a commercially available spreadsheet program that is user friendly and widely utilized. The database program BOM-CMRR.WK3 is written for Lotus 1-2-3, release 3.1, which is used with DOS 3.0 or later versions. Your computer must have a minimum of 1 Mb of memory available for Lotus 1-2-3. If you are

DATA BASE SUMMARY OF GATE ROAD ROOF STUDY

TABLE 1.- Roof control planning and coal quality prediction

LOCATION IN 7 LEFT GATE ROAD (DISTANCE OUTBY) (CROSSCUT 25)	ROOF FALL HAZARD DATA			COAL QUALITY DATA	
	CMRR	UNIT RATING 1	THICKNESS UNIT 1	COAL QUALITY FACTOR 1	COAL QUALITY FACTOR 2
0	82	82	1.8m (6ft)	Bone band pinched out	Carbon. mudstone bands thinning
61 m (200 ft)	82	82	1.8m (6ft)	Bone band pinched out	Carbon. mudstone bands thinning
122 m (400 ft)	81	82	1.6m (5.2ft)	Bone band pinched out	Carbon. mudstone bands thinning
176 m (575 ft)	85	9	.3m (1ft)	Bone band thinning	Carbon. mudstone bands thinning
244 m (800 ft)	92	92	1.8m (6ft)	Bone band thinning	Carbon. mudstone bands present
305 m (1000 ft)	92	92	1.8m (6ft)	Bone band thinning	Carbon. mudstone bands present
352 m (1150 ft)	92	92	1.8m (6ft)	Bone band thinning	Carbon. mudstone bands present
436 m (1425 ft)	61	9	.15m (0.5ft)	Bone band pinched out	Carbon. mudstone bands present
497 m (1625 ft)	51	9	.15m (0.5ft)	Bone band pinched out	Carbon. mudstone bands present
566 m (1850 ft)	84	92	1.5m (5ft)	Bone band present	Carbon. mudstone bands present
610 m (2000 ft)	80	9	.15m (0.5ft)	Bone band present	Carbon. mudstone bands present
671 m (2200 ft)	79	9	.15m (0.5ft)	Bone band present	Carbon. mudstone bands present

TABLE 2.- Bolted roof rank from low to high

DISTANCE OUTBY CROSSCUT 25	CMRR	RANK
497 m (1625 ft)	51	Moderate
436 m (1425 ft)	61	Moderate
671 m (2200 ft)	79	Strong
610 m (2000 ft)	80	Strong
122 m (400 ft)	81	Strong
0	82	Strong
61 m (200 ft)	82	Strong
566 m (1850 ft)	84	Strong
176 m (575 ft)	85	Strong
244 m (800 ft)	92	Strong
305 m (1000 ft)	92	Strong
352 m (1150 ft)	92	Strong

TABLE 3.- Hazard map data

ROOF FALL HAZARD LOCATION (DISTANCE OUTBY CROSSCUT 25)	UNIT RATING AND THICKNESS OF IMMEDIATE ROOF UNIT 1
176 m (575 ft)	9 at .3 m (1 ft)
436 m (1425 ft)	9 at .15 m (0.5 ft)
497 m (1625 ft)	9 at .15 m (0.5 ft)
610 m (2000 ft)	9 at .15 m (0.5 ft)
671 m (2200 ft)	9 at .15 m (0.5 ft)

Figure 9.—Sample printout of CMRR database summary.

using Lotus 1-2-3, release 3.1 with Windows 3.0 in 386 enhanced mode and have only 2 Mb of memory, you should create a permanent Windows 3.0 swap file. The database program was written for users with little knowledge of Lotus 1-2-3 commands or for experienced users.

After the Lotus 1-2-3 program is started and the file BOM-CMRR.WK3 is retrieved into the worksheet area, the user will be viewing the main worksheet B of the database program (figure 10). Worksheet B contains a blank duplicate of the CMRR field data worksheet, additional roof characteristics section, comments section, CMRR summary section, CMRR conversion tables, Lotus 1-2-3 programming code, and Lotus 1-2-3 macro code. The blank duplicate of the field data worksheet provides space for six roof units with four discontinuities each per field test. A partial list of the programming and macro code, with explanatory remarks, is shown in appendix B. This code is provided for users who prefer to customize BOM-CMRR.WK3 for their own specific problem.

The program BOM-CMRR.WK3 has a three-dimensional structure. It consists of a series of layered worksheets (figure 11). After data from a single CMRR field test are entered into the correct cell locations on worksheet B, CMRR parameters are calculated and the field data worksheet, additional roof characteristics, comments, and CMRR summary are copied to and stored in worksheet C (field test 1 in figure 11). Worksheet B is then cleared and data from field test 2 are entered. CMRR parameters are calculated and the information is copied to and stored in worksheet D (field test 2 in figure 11). The process is repeated until all field test data

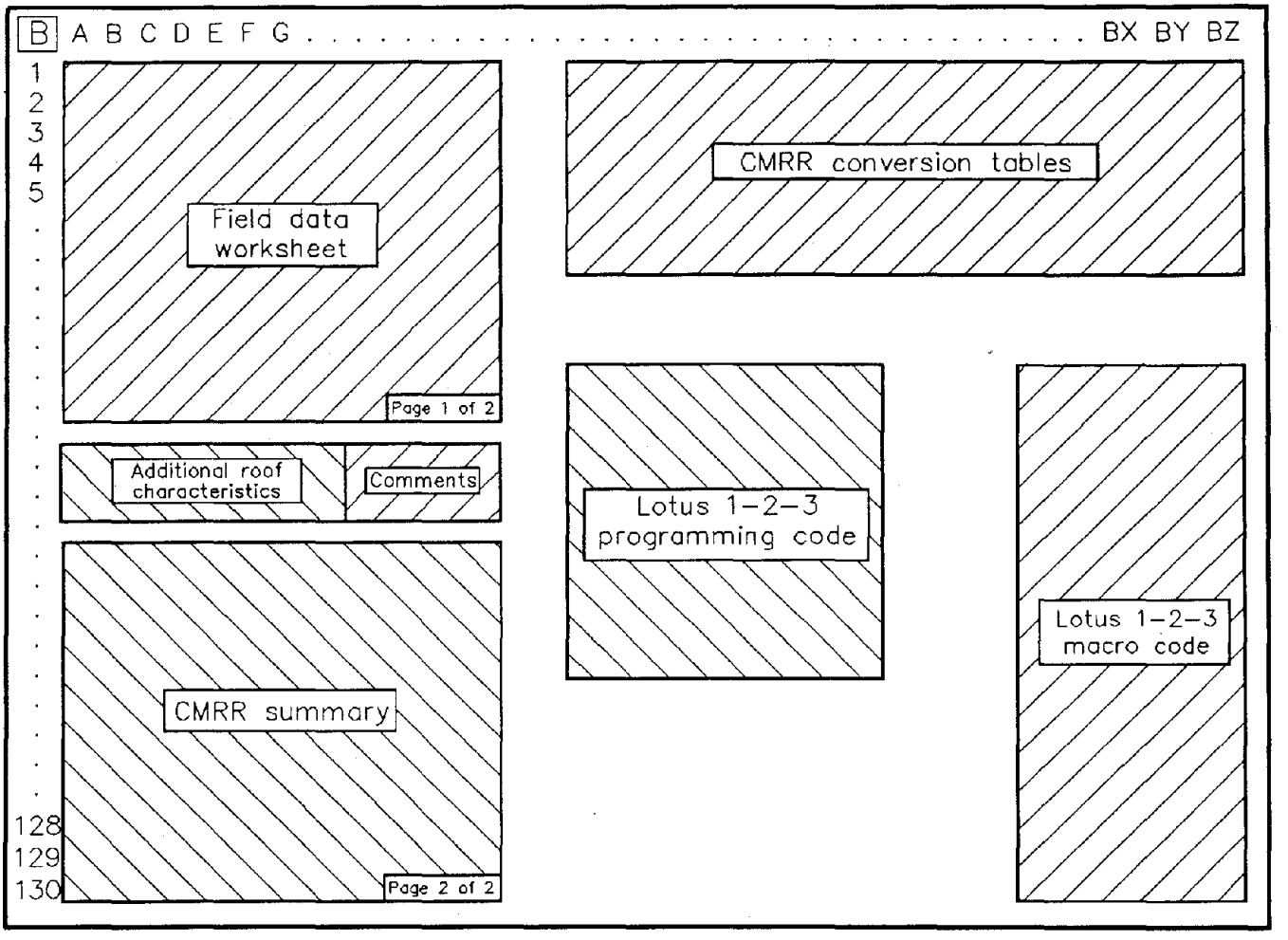


Figure 10.—Sections of main Lotus 1-2-3 worksheet B.

worksheets from a ground control study are entered. New field tests are stored in back of previously entered tests so that the worksheet reference letter (i.e., C, D, and E) remains the same for each test as the database is expanded. Up to 254 field tests can be added, depending on how much memory a computer has.

The Lotus 1-2-3 program has the capability to search each worksheet of the database and perform queries, sorts, merges, and statistics. Pertinent information can also be copied to text files to interface it with other software packages. Worksheet A is reserved for building a database summary report containing this information (figure 9).

OPERATING INSTRUCTIONS

To use the Lotus 1-2-3 program, perform the following steps.

1. Copy the BOM-CMRR.WK3 master program file from the floppy disk[9] to the Lotus 1-2-3 directory on the hard drive of your personal computer.

2. Start Lotus 1-2-3 program and execute a file retrieve command (/**FR**) to retrieve file BOM-CMRR.WK3 from the hard drive.

3. Before doing any work, execute a file save command (/**FS**) to create a new file on the hard drive with a name other than BOM-CMRR.WK3. For example, if you are creating a database to store and evaluate CMRR field test data for the 7 Left gate road at your mine, the new file can be named "7L-GTRD.WK3." At this point, there are two CMRR database files on your hard drive: the master program file BOM-CMRR.WK3 (which is an empty shell with programming code contained in it) and the file you

[9]See footnote 3.

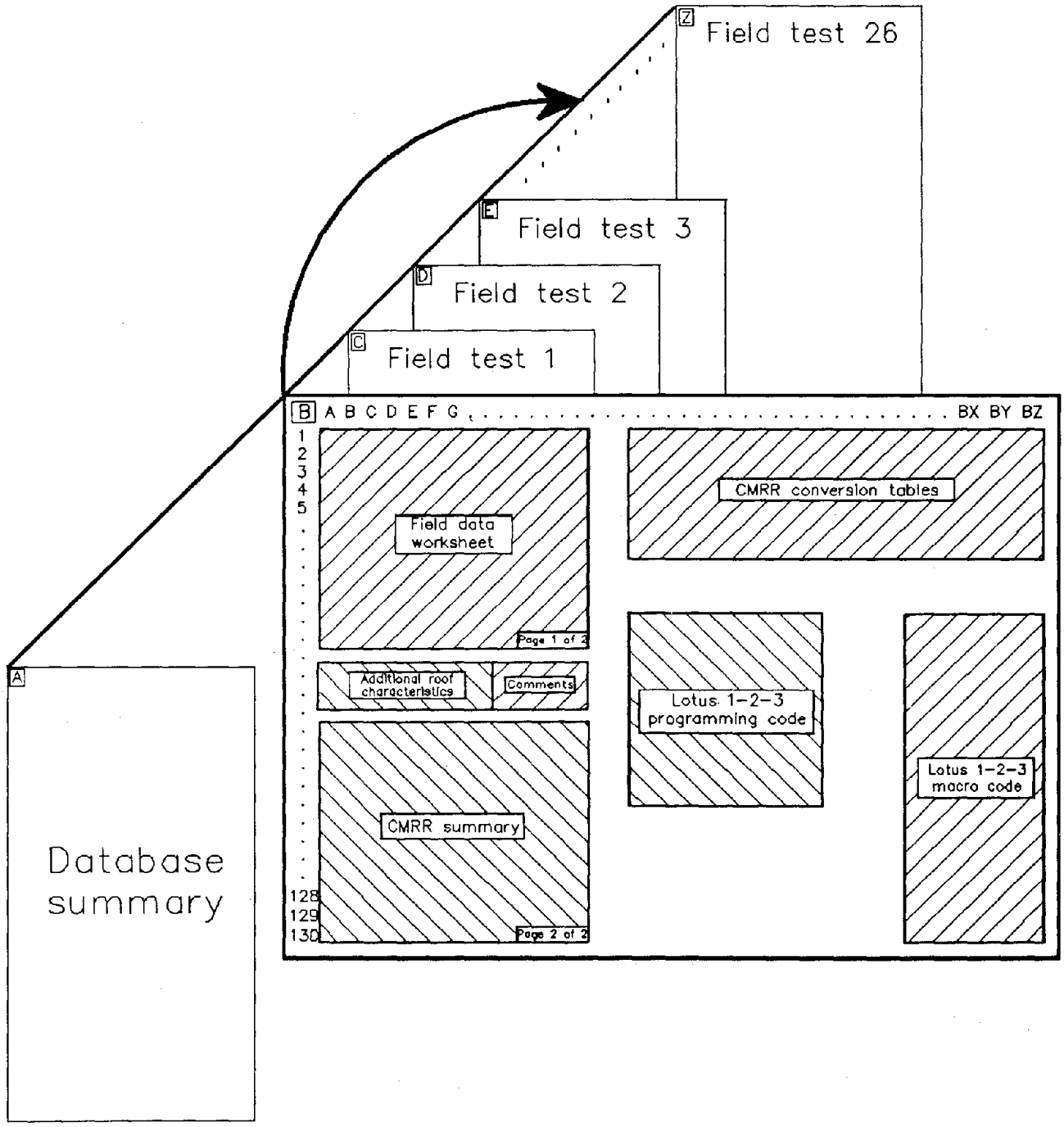
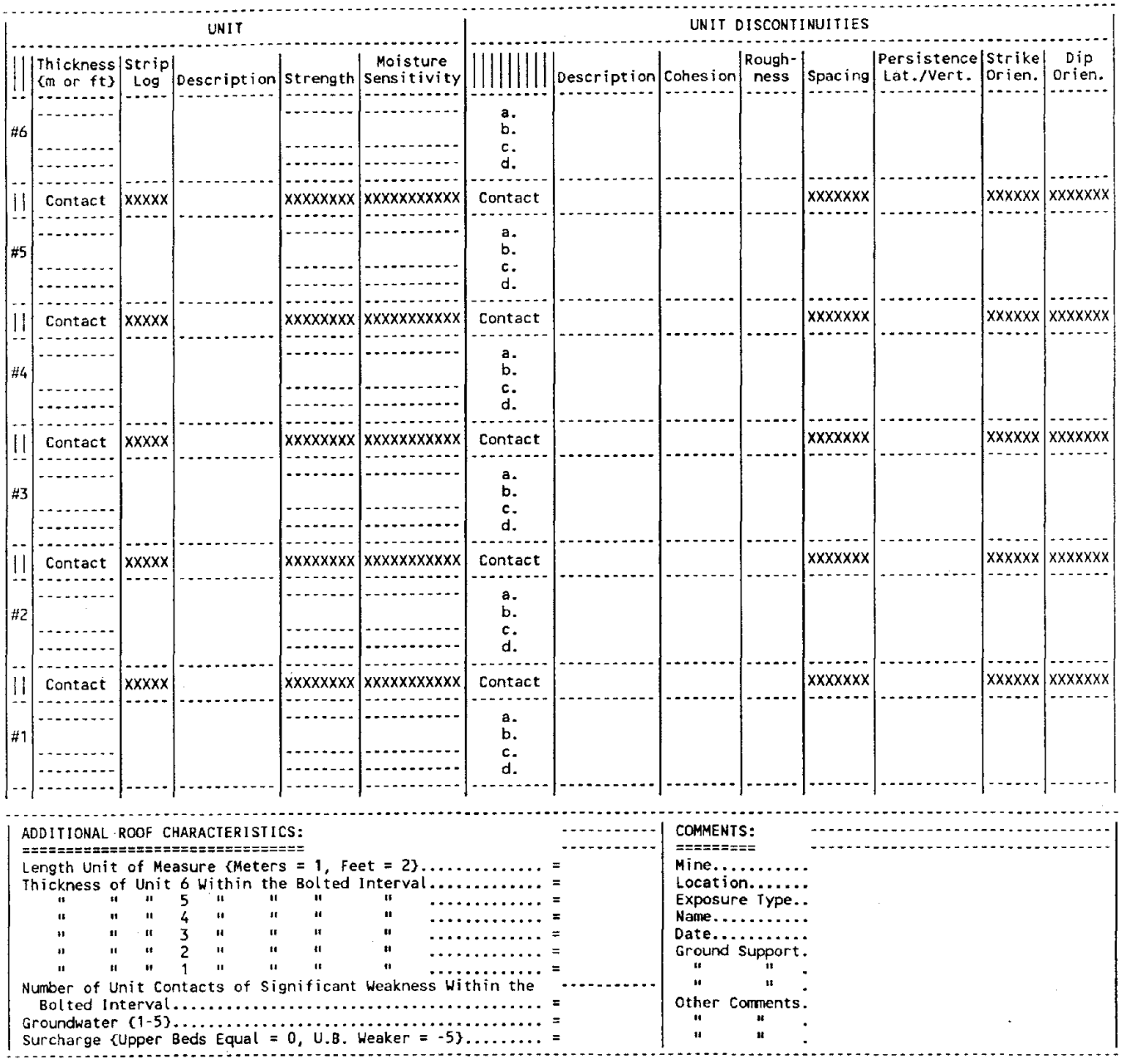


Figure 11.—Three-dimensional database structure of Lotus 1-2-3 spreadsheet.

are creating (7L-GTRD.WK3). Creating a new file ensures that the master program file will not be altered and can be used to create new files in the future.

4. Transfer the information from the first CMRR field test to the appropriate data input cells in the field data worksheet (figure 12). The following list specifies the CMRR parameters to be input into the Lotus 1-2-3 worksheet.

Unit thickness is entered into the blank cells in column D.



	UNIT					UNIT DISCONTINUITIES							
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
#6						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#5						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#4						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#3						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#2						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#1						a. b. c. d.							

ADDITIONAL ROOF CHARACTERISTICS:

Length Unit of Measure (Meters = 1, Feet = 2)..... =
Thickness of Unit 6 Within the Bolted Interval..... =
" " " 5 " " " " ..... =
" " " 4 " " " " ..... =
" " " 3 " " " " ..... =
" " " 2 " " " " ..... =
" " " 1 " " " " ..... =
Number of Unit Contacts of Significant Weakness Within the Bolted Interval..... =
Groundwater (1-5)..... =
Surcharge (Upper Beds Equal = 0, U.B. Weaker = -5)..... =

COMMENTS:

Mine.....
Location.....
Exposure Type..
Name.....
Date.....
Ground Support.
" " .
" " .
Other Comments.
" " .
" " .

Figure 12.—Work area of main Lotus 1-2-3 worksheet B.

Strip log information can be drawn in by hand on the hard copy printout (figure 13).

Unit description is entered into the blank cells in column H. Each unit has four blank cells available for the description.

Unit strength and moisture sensitivity are entered into the blank cells in columns J and L, respectively.

Unit discontinuity description is entered into the blank cells in column P. Each unit can have up to four discontinuities (a., b., c., and d.) and each discontinuity has one blank cell available for description. If the unit has no discontinuities, enter **Intact rock** into the description cell of discontinuity a.

Cohesion, roughness, spacing, persistence, strike, and dip are entered into the blank cells in columns R, T, V, X, Z, and AB, respectively.

Length unit of measure is entered into column P of the "Additional Roof Characteristics" section. Length can be entered in meters (1) or feet (2).

Thicknesses of the units within the bolted interval are entered into column P of the "Additional Roof Characteristics" section. If a unit is not within the bolted interval, the thickness cell can be left blank.

A

XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXXX
XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXXX

	UNIT					UNIT DISCONTINUITIES							
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
#6						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#5	4		Tan sandstone	2	1	a. b. c. d.	Intact rock	2	2.5				
	Contact	XXXXX	Graded	XXXXXXXX	XXXXXXXXXX	Contact	Graded			XXXXXXX		XXXXXX	XXXXXXX
#4	1		Black shale	3	2	a. b. c. d.	Joints	3	3	4	4	N10W	88N
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#3	1		Coal rider seam	5	2	a. b. c. d.	Face cleat Butt cleat	2 1	3 3	4 3	4 4	N25E N62W	40NW 17NE
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#2	2		Poker chip shale	4	2	a. b. c. d.	Bedding Joints Nodules	3 2.5 2	3 2.5 2	5 4 3	1 4 2	N45W	85NE
	Contact	XXXXX	Graded	XXXXXXXX	XXXXXXXXXX	Contact	Graded			XXXXXXX		XXXXXX	XXXXXXX
#1	1.5		Gray shale	3	3	a. b. c. d.	Laminations K. bottoms Slips Nodules	2 3 4 2	3 1 2 2	4 1 2 3	4 4 3 2		
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
	UNIT					UNIT DISCONTINUITIES							

XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXXX
XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXXX

B

ADDITIONAL ROOF CHARACTERISTICS:

Length Unit of Measure (Meters = 1, Feet = 2)	= 2
Thickness of Unit 6 Within the Bolted Interval	=
" " " 5 " " " "	= 1.5
" " " 4 " " " "	= 1
" " " 3 " " " "	= 1
" " " 2 " " " "	= 2
" " " 1 " " " "	= 1.5
Number of Unit Contacts of Significant Weakness Within the Bolted Interval	= 2
Groundwater (1-5)	= 3
Surcharge (Upper Beds Equal = 0, U.B. Weaker = -5)	=

COMMENTS:

Mine.....DRC #1
Location.....2 Left, XC-44
Exposure Type..Roof fall
Name.....Bill Wuest
Date.....9/2/93
Ground Support.2.14-m (7-ft) resin grouted bolts,
" " .Steel pans, Wood posts on left
" " .side of entry looking inby
Other Comments.Rib sloughage in this area
" " .
" " .

****CMRR = 54 ****

CMRR SUMMARY

INDIVIDUAL DISCONTINUITY RATINGS:

Unit 1 IDRa = 38	Unit 2 IDRa = 25	Unit 3 IDRa = 38
" IDRb = 54	" IDRb = 35	" IDRb = 70
" IDRc = 35	" IDRc = 48	" IDRc =No data
" IDRd = 48	" IDRd =No data	" IDRd =No data
Unit 4 IDRa = 29	Unit 5 IDRa = 61	Unit 6 IDRa =No data
" IDRb =No data	" IDRb =No data	" IDRb =No data
" IDRc =No data	" IDRc =No data	" IDRc =No data
" IDRd =No data	" IDRd =No data	" IDRd =No data

UNIT RATINGS:

IDR 1 (lowest) = 35	IDR 2 (lowest) = 25	IDR 3 (lowest) = 38
MDA 1 = -4	MDA 2 = -4	MDA 3 = 0
US 1 = 15	US 2 = 10	US 3 = 5
MS 1 = -10	MS 2 = -3	MS 3 = -3
Unit Rating 1 = 36	Unit Rating 2 = 28	Unit Rating 3 = 40
IDR 4 (lowest) = 29	IDR 5 (lowest) = 61	IDR 6 (lowest) =No data
MDA 4 = 0	MDA 5 = 0	MDA 6 =No data
US 4 = 15	US 5 = 22	US 6 =No data
MS 4 = -3	MS 5 = 0	MS 6 =No data
Unit Rating 4 = 41	Unit Rating 5 = 83	Unit Rating 6 =No data

COAL MINE ROOF RATING:

	Unit Rating		Bolted Thickness		
UR 1	36	X	1.5	=	54
UR 2	28	X	2	=	56
UR 3	40	X	1	=	40
UR 4	41	X	1	=	41
UR 5	83	X	1.5	=	124.5
UR 6	No data	X	No data	=	No data
Sum		=	7		315.5

Weighted Average of the Unit Ratings = 45

RRW =	45
Strong Bed Adjustment =	15
Bed Contact Adjustment =	-2
Groundwater Adjustment =	-4
Surcharge Adjustment =	
CMRR =	54

Figure 13.—Sample printout of field test data and CMRR parameters, including individual discontinuity rating (IDR), multiple discontinuity adjustment (MDA), unit strength (US), moisture sensitivity (MS), unit rating (UR), and weighted average of unit ratings (RRW). *A*, Page 1 with field data; *B*, page 2 with additional field data and CMRR summary.

Bed contact and groundwater adjustments are entered into column P of the "Additional Roof Characteristics" section.

Surcharge adjustment is entered into column P of the "Additional Roof Characteristics" section. If the upper units are approximately equal in strength to the bolted interval, enter 0. If the upper units are significantly weaker than the bolted interval, enter -5. If the upper units are significantly stronger than the bolted interval, leave the cell blank.

Comments are entered into the blank cells of column V. Each line can contain up to 34 characters. The "Comments" section is available for users to record and analyze any information that is important to their own specific problems (e.g., roof support, coal quality, and rib quality), but comment information is not necessary for CMRR calculations.

Half values can be entered for strength, cohesion, roughness, spacing, and persistence (e.g., strength = 2.5). Strike and dip orientation do not have to be entered in order for the program to calculate CMRR. A sample printout of field test data and CMRR parameters is shown in figure 13.

5. Run the program by pressing the <Alt> and <R> keys simultaneously. The program automatically computes CMRR parameters and enters these values into the CMRR summary section of the main spreadsheet B.

6. Print the report by pressing the <Alt> and <P> keys simultaneously. A two-page hard copy of CMRR data and results is automatically printed. The sample printout shown in figure 13 was printed on letter-size paper using condensed print. If the printer is set for normal size print, the report fits on 15- by 11-in computer paper. Either print format can be reduced on a copy machine to provide any final hard copy size desired.

7. Transfer the field data worksheet, additional roof characteristics, comments, and CMRR summary from the first CMRR field test to worksheet C (figure 10) by pressing the <Alt> and <C> keys simultaneously. This function also saves the working file in the Lotus 1-2-3 directory of the hard drive.

8. Clear the data input cells in the main worksheet B by pressing the <Alt> and <L> keys simultaneously. In order for the "Comments" section to be cleared correctly, comments must be placed in the cells of column V.

At this point, the user is ready to repeat steps 4 through 8 for the remaining CMRR field test worksheets completed during the ground control study. If there is little difference between consecutive field test worksheets, there is no need to clear the data input cells before beginning new input. Simply alter the few cells that are different, then repeat steps 5 through 7.

For users with limited knowledge of Lotus 1-2-3 program commands, it would be helpful to work through the lessons in the Lotus 1-2-3, release 3.1 tutorial book (Lotus Development Corp., 1990). In this book, chapter 3 "Using Multiple Worksheets and Files" and chapter 5 "Automating Your Work With Macros" are most applicable to the BOM-CMRR.WK3 program file. Any of the manual Lotus 1-2-3 commands can also be used within the database to perform such functions as editing, deleting worksheets, copying worksheets, transferring worksheets to new locations, clearing cell locations, and printing reports. Be careful NOT to perform any manual commands while working in the main worksheet B that will alter the programming code contained there. If this happens, you will need to start over with a backup copy of BOM-CMRR.WK3 that you should always keep on a floppy disk. And at the end of each working session, save your work. BOM-CMRR.WK3 is also compatible with other commercial spreadsheet programs such as the widely used Excel program. A Lotus 1-2-3 for Windows version of this spreadsheet is currently under development by the USBM.

SAMPLE APPLICATION FROM GATE ROAD ROOF STUDY AT A WESTERN U.S. COAL MINE

Appendix C contains a sample CMRR database created with computer file BOM-CMRR.WK3. Field data worksheets were filled out at 12 locations along a gate road at a Western U.S. coal mine; then the mining information was transferred to and processed by the database program. The roof in the gate road has a sandstone channel, mudstone member, and carbonaceous mudstone member, and the bolt length is 1.8 m (6 ft). Unit thicknesses for the roof members change throughout the gate road as the sandstone channel changes shape. As the thicknesses change, CMRR and UR of the first roof layer also change (figure 14). Channel boundaries are characterized by hazardous roof conditions. For the example shown in appendix C, the hazard areas can be mapped using the UR of the first roof layer. The graph shown in figure 14 can also be used to determine what type of roof control conditions may be expected for certain values of CMRR and UR.

After all the mining information from a ground control study has been entered into the CMRR database, the database can be printed, as shown in appendix C, to evaluate the information contained in it, or graphs, maps, statistical analyses, and database summary reports can be prepared for evaluation. First-time users of computer file BOM-CMRR.WK3 can review appendix C to gain insight on what information is needed to create a CMRR database, into what cell locations the information is entered, and what a sample CMRR database summary (figure 9) may look like if the program is run correctly.

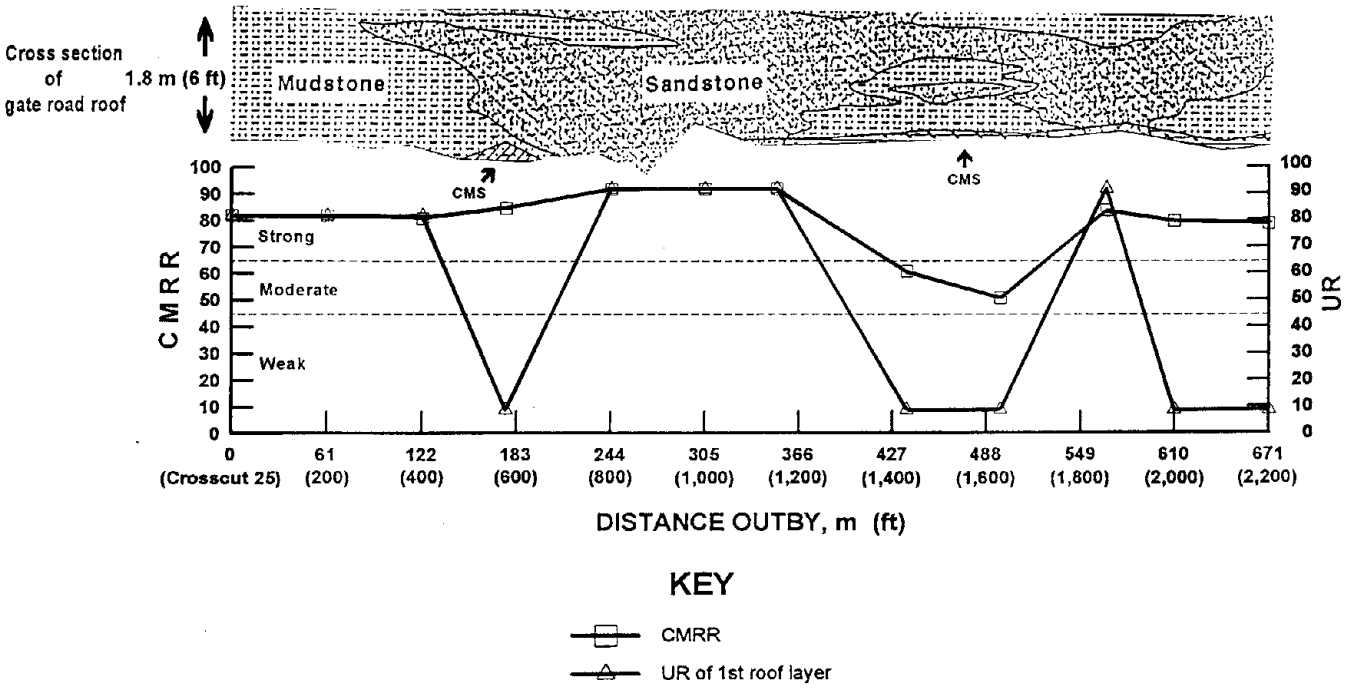


Figure 14.—CMRR results from gate road roof study at a western U.S. coal mine showing carbonaceous mudstone (CMS) member and unit ratings (UR's) of first immediate roof layer.

Since each mine has a unique set of conditions, database evaluation should be customized to fit the specific problems of a mine. At a mine experiencing roof falls and coal quality problems, a database summary like the one shown in figure 9 may be created to chart these factors. Lotus 1-2-3 commands were used in worksheet A (figure 10) to query, merge, sort, and print pertinent information related to roof control planning, coal quality prediction, roof structure competence, and hazard mapping. Reports can also be made to evaluate any other information contained in the field data worksheet (e.g., artificial support type, pillar characteristics, rib quality, groundwater, and roof unit thicknesses).

CONCLUSIONS

The CMRR is a tool developed by the USBM for aiding coal pillar and entry design, intersection span design, and mine roof support design as it is widely accepted that "bad" roof results in hazardous ground conditions. The CMRR may also be used to produce a map of the roof quality throughout an active coal mine, indicating zones of *weak*, *moderate*, or *strong* roof. For areas or zones of weak roof rock, one may alter a support plan to accommodate this potential problem area. This type of map may also be utilized as a hazard map when various types of data are combined onto layered mapping systems to detect zones of potential weakness based on numerous geotechnical information. Rapid changes in rating (e.g., across a gate road) from strong to weaker or weak to stronger may signal an area of possible hazard due to an abrupt change in geology. Detecting rock property boundaries such as channel sands or mud stringers may help to anticipate potential hazards from these boundary effects. The USBM is currently investigating combining the CMRR and geologic mapping with a geostatistical modeling package. These maps then, combined with numerically modeled stress profiles, may help to forecast areas of potential hazard ahead of mining and/or development.

Two methods for computing the CMRR have been developed by the USBM. The first of these methods is a family of stand-alone, c-language programs for all personal computer users. The c programs accept interactive user input of field data, compute a CMRR, output the CMRR's to text files, and display the ratings in two different ways. Text file output from the c programs can be read directly into a number of graphing and analysis program packages, such as Grapher, Surfer, AutoCAD, and ARC/INFO, among others. The second method is a Lotus 1-2-3 worksheet that may be preferred by users of spreadsheet

programs. The worksheet accepts user input for the storage of raw field data and computes, stores, and prints the CMRR parameters using simple macro commands. In addition, Lotus 1-2-3 software is a powerful tool for manipulating and analyzing tabular data; thus site-specific reports can be easily generated.

ACKNOWLEDGMENTS

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APPENDIX A.—INSTALLATION OF CMRR FAMILY OF PROGRAMS

The CMRR family of programs are written in the c programming language (Microsoft C, version 6.0) and are written for personal computers using the DOS operating system. A variable gain amplifier (VGA) monitor is required for running the graphics portions of the program; yet it is not required to perform the calculations and creation of data files. The executable programs and the c source code for the seven programs are on the floppy disk.[1] These programs can be run directly from the floppy disk drive, although copying them to an area on your hard drive (assuming you have one) is recommended. To copy the programs to your hard disk drive, first create a subdirectory named "CMRR" (or whatever suits you), and type **cd** to access this CMRR directory (assuming that the hard drive is the c: drive). Place the floppy disk in drive a: (or b: if required). From the CMRR directory, after the computer prompts *c:\CMRR*, simply type **copy a:*.*** and press <Enter>. All files from the floppy disk will be copied to your hard drive. Storage for the complete program set is slightly more than 460 kb. The Lotus 1-2-3 spreadsheet, also contained on the disk, requires an additional 65 kb. All executable program files end with an *.exe extension and all c-language source code files end with an *.c extension. Files that end in *.dat, *.out, and *.map are sample files corresponding to the examples presented within this Information Circular. These sample files are (1) USBMtest.dat (sample raw field data text file), (2) USBMtest.out (sample output ratings for test data file), (3) USBMtest.log (sample output ratings in database form), and (4) Mine.map (sample mine map input file). Files that end in *.fon are font files necessary to display graphics on the screen. Also included on this disk is the Lotus 1-2-3 spreadsheet file (*.wk3) for storing field data and computing a CMRR.

To begin the CMRR program, after the program prompts *c:\CMRR*, type **CMRR** and press <Enter>. You are now running the program. To run any of the other programs, type the program name similar to the example given here. To abort any of the programs at any time, press <Ctrl> and <C> simultaneously. Use caution when aborting a program to avoid losing data entered during the session.

There are two known problems in the family of programs. After the output from the Rockplot, Rockmplt, and Stratplt programs are viewed, a null-pointer assignment error often appears on the screen. This doesn't affect anything; the problem has not been found. At this time just ignore the message (although suggestions are welcome). The second problem is encountered when the Stratplt program does not exit the plot properly and may lock up the monitor. This has happened on a single high-resolution, 17-in monitor and appears to be triggered by the different brands of personal computers and monitors used since this has not been observed on more common personal computers and monitors. Again, suggestions are welcome.

[1]See page 2 for explanation of footnote 3.

APPENDIX B.—LOTUS 1-2-3 PROGRAMMING CODE AND MACROS

The following portions of the programming code and macro commands are shown in figures B-1 through B-3 for users who prefer to customize computer file BOM-CMRR.WK3 for their own specific problem or for those who want to write a similar worksheet program but are not familiar with Lotus 1-2-3 commands.

```
                Lowest Individual Discontinuity Rating {IDR}
                ============================================

REMARK Determine if any of the units have no discontinuities and the
REMARK cohesion-roughness test was done on intact rock
@IF(P9="Intact rock",1,0)

REMARK Calculate IDRs for each Unit
@IF(AF21=1,@INDEX(AG10..AN15,2*R9-1,2*T9-1)+35,@INDEX(AG10..AN15,2*R9-1,
    2*T9-1)+@INDEX(AQ10..AZ17,2*V9-1,2*X9-1))
@INDEX(AG10..AN15,2*R10-1,2*T10-1)+@INDEX(AQ10..AZ17,2*V10-1,2*X10-1)
@INDEX(AG10..AN15,2*R11-1,2*T11-1)+@INDEX(AQ10..AZ17,2*V11-1,2*X11-1)
@INDEX(AG10..AN15,2*R12-1,2*T12-1)+@INDEX(AQ10..AZ17,2*V12-1,2*X12-1)

REMARK Determine how many discontinuities are entered
@ISERR(AH21),ISERR(AH22),ISERR(AH23)

REMARK Determine lowest IDR for each Unit
@IF(AI21=0#AND#AI22=1,AH21,1000)
@IF(AI22=0#AND#AI23=1,@MIN(AH21..AH22),1000)
@IF(AI23=0#AND#AI24=1,@MIN(AH21..AH23),1000)
@IF(AI24=0,@MIN(AH21..AH24),1000)
@MIN(AJ21..AJ24)

                Multiple Discontinuity Adjustment {MDA}
                =======================================

REMARK Arrange Unit IDRs for sorting
@IF(AI21=0,AH21,1000)
@IF(AI22=0,AH22,1000)
@IF(AI23=0,AH23,1000)
@IF(AI24=0,AH24,1000)

REMARK Determine MDA for each Unit
@IF(AN22=1000,0,1000)
@IF(AP21=1000#AND#AN21>50,0,1000)
@IF(AP21=1000#AND#AN22>50,0,1000)
@IF(AP21=1000#AND#AN21<50#AND#AN22<50,-2,1000)
@IF(AP21=1000#AND#AN21<40#AND#AN22<40,-4,1000)
@IF(AP21=1000#AND#AN21<30#AND#AN22<30,-5,1000)
@MIN(AP21..AP26)

                          Unit Rating {UR}
                          ================

REMARK Determine UR for each Unit
@IF(AK21=1000,1/0,AK21)
@IF(AK21=1000,1/0,AR21)
@IF(AK21=1000,1/0,@INDEX(BH9..BI14,1,J10))
@IF(AK21=1000,1/0,@INDEX(BL9..BM13,1,L10))
@SUM(AT21..AT24)
```

Figure B-1.—Programming code for calculation of lowest individual discontinuity rating, multiple discontinuity adjustment, and unit rating.

```
                Weighted Average of the Unit Ratings {RRW}
                ==========================================

REMARK_Determine RRW for the mine area of the roof test
@IF(AK21=1000,@FALSE,AT25)
+P60,+P61,+P62,+P63,+P64,+P65
@SUM(AW21..AW26)
+AV21*AW21
@SUM(AX21..AX26)
@ROUND(+AX27/AW27,0)

                        Strong Bed Adjustment {SBA}
                        ===========================

REMARK_Determine which Units are at least 1 foot thick
@IF(P60>11,1,0)

REMARK_Determine which Units have a UR at least 5 points higher than RRW
@IF(AK21=1000,0,@IF(AT25-AY27>4,1,0))

REMARK_Determine which Units meet both SBA criteria and arrange their
REMARK_respective URs for the sorting macro Alt-S
@IF(BA21=1#AND#BB21=1,AT25,0)

REMARK_Determine strong bed difference and difference range
+BE21-AY27
@IF(BA36>4.99#AND#BA36<9.99,1,1000)
@IF(BA36>9.99#AND#BA36<14.99,2,1000)
@IF(BA36>14.99#AND#BA36<19.99,3,1000)
@IF(BA36>19.99#AND#BA36<24.99,4,1000)
@IF(BA36>24.99#AND#BA36<29.99,5,1000)
@IF(BA36>29.99#AND#BA36<34.99,6,1000)
@IF(BA36>34.99#AND#BA36<40.01,7,1000)
@IF(BA36>40.01,8,1000)
@MIN(BD28..BD35)

REMARK_Determine strong bed thickness and thickness range
@IF(AK21=1000,0,@IF(AT25=BE21,D10,0))
@SUM(BA28..BA33)/12
@IF(BA34>0.99#AND#BA34<1.99,1,1000)
@IF(BA34>1.99#AND#BA34<2.99,2,1000)
@IF(BA34>2.99#AND#BA34<3.99,3,1000)
@IF(BA34>3.99,4,1000)
@MIN(BB28..BB31)

                        Bed Contact Adjustment
                        ======================

REMARK_Determine range of number of bed contacts
@IF(P67=0,1,1000)
@IF(P67>0.99#AND#P67<2.01,2,1000)
@IF(P67>2.99#AND#P67<4.01,3,1000)
@IF(P67>4.01,4,1000)
@MIN(BG28..BG31)
```

Figure B-2.—Programming code for calculation of weighted average of unit ratings, strong bed adjustment, and bed contact adjustment.

```
                    Roof Rating {CMRR}
                    ==================

REMARK_Determine CMRR
+AY27
@IF(BE21=0,0,@INDEX(BQ11..BY15,BD36,BB32))
@INDEX(CB10..CC14,1,BG32)
@INDEX(CG9..CH14,1,P68)
+P70
@SUM(BG21..BG25)

                    CMRR MACROS
                    ===========

REMARK_ALT-R calculates CMRR parameters.
{LET AN21,AM21}{LET AN22,AM22}
{LET AN23,AM23}{LET AN24,AM24}
/DSDAN26..AN29~PAN26~A~G

REMARK_ALT-P prints out 2 page hard copy of CMRR parameters and results.
/PPRA1..AC63~OML3~MR165~MTO~MBO~P66~
OBSQAGPR{ESC}A64..AC126~OOBSQAGPQ

REMARK_ALT-C adds blank worksheet to the data base file.  Copies data
REMARK_and CMRR results from the working area of worksheet B to the
REMARK_blank worksheet.  Saves file in the current directory.
{HOME}{PGDN}{END}{NS}/WISA1~{PGDN}{END}{PS}{NS}/CA1..AC126~{HOME}{PGDN}
{END}{NS}{HOME}~/FS~R

REMARK_ALT-L Clears data input cells in the working area of
REMARK_worksheet B.
{HOME}{R 3} {D P} {D 7} {R 5} {U 5} {L 30} ~{HOME}
```

Figure B-3.—Programming code for calculation of roof rating and execution of macro commands.

APPENDIX C.—SAMPLE CMRR DATABASE FROM STUDY OF GATE ROAD ROOF AT A WESTERN U.S. COAL MINE

The two-page printouts of the mining information collected at each location along the gate road shown in figure 14 are shown in this appendix as figures C-1 through C-12. Information that is highlighted was used to create the CMRR database summary report of figure 9.

A

XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX
XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX

UNIT						UNIT DISCONTINUITIES							
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
#6						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#5						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#4						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#3						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#2						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#1	6		Mudstone	3	2	a.	Bedding	1	2	3	2		
						b. c. d.							
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
UNIT						UNIT DISCONTINUITIES							

XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXX
XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXX

B

ADDITIONAL ROOF CHARACTERISTICS:

Length Unit of Measure (Meters = 1, Feet = 2).............. = 2
Thickness of Unit 6 Within the Bolted Interval.............. =
" " " 5 " " " " .... =
" " " 4 " " " " .... =
" " " 3 " " " " .... =
" " " 2 " " " " .... =
" " " 1 " " " " .... = 6
Number of Unit Contacts of Significant Weakness Within the Bolted Interval.............. = 0
Groundwater (1-5).............. = 1
Surcharge (Upper Beds Equal = 0, U.B. Weaker = -5).......... = 0

COMMENTS:

Mine...........Western US
Location.......7 Left gate road, XC-25
Exposure Type..Gate road roof X-section diagram
Name...........B. Wuest
Date...........10/15/93
Ground Support.1.8-m (6-ft) resin grouted bolts
" " .
" " .
Other Comments.Bone band pinched put
" " .Carbon, mudstone bands thinning
" " .

****CMRR = 82 ****

CMRR SUMMARY

INDIVIDUAL DISCONTINUITY RATINGS:

Unit 1 IDRa = 70
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 2 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 3 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 4 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 5 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 6 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

UNIT RATINGS:

IDR 1 (lowest) = 70
MDA 1 = 0
US 1 = 15
MS 1 = -3
Unit Rating 1 = 82

IDR 2 (lowest) =No data
MDA 2 =No data
US 2 =No data
MS 2 =No data
Unit Rating 2 =No data

IDR 3 (lowest) =No data
MDA 3 =No data
US 3 =No data
MS 3 =No data
Unit Rating 3 =No data

IDR 4 (lowest) =No data
MDA 4 =No data
US 4 =No data
MS 4 =No data
Unit Rating 4 =No data

IDR 5 (lowest) =No data
MDA 5 =No data
US 5 =No data
MS 5 =No data
Unit Rating 5 =No data

IDR 6 (lowest) =No data
MDA 6 =No data
US 6 =No data
MS 6 =No data
Unit Rating 6 =No data

COAL MINE ROOF RATING:

	Unit Rating		Bolted Thickness	
UR 1	82	X	6	= 492
UR 2	No data	X	No data	=No data
UR 3	No data	X	No data	=No data
UR 4	No data	X	No data	=No data
UR 5	No data	X	No data	=No data
UR 6	No data	X	No data	=No data
Sum	=		6	492

Weighted Average of the Unit Ratings = 82

RRW =	82
Strong Bed Adjustment =	0
Bed Contact Adjustment =	0
Groundwater Adjustment =	0
Surcharge Adjustment =	0
CMRR =	82

Figure C-1.—Mining information from crosscut 25. *A*, Page 1 with field data; *B*, page 2 with additional field data and CMRR summary.

A

XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX
XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX

	UNIT					UNIT DISCONTINUITIES							
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
						a.							
#6						b.							
						c.							
						d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
						a.							
#5						b.							
						c.							
						d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
						a.							
#4						b.							
						c.							
						d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
						a.							
#3						b.							
						c.							
						d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
						a.							
#2						b.							
						c.							
						d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
						a.	Bedding	1	2	3	2		
#1	6		Mudstone	3	2	b.							
						c.							
						d.							
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
	UNIT					UNIT DISCONTINUITIES							

XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXXX
XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXXX

B

ADDITIONAL ROOF CHARACTERISTICS:

Length Unit of Measure (Meters = 1, Feet = 2)	2
Thickness of Unit 6 Within the Bolted Interval	
" " " 5 " " " "	
" " " 4 " " " "	
" " " 3 " " " "	
" " " 2 " " " "	
" " " 1 " " " "	6
Number of Unit Contacts of Significant Weakness Within the Bolted Interval	0
Groundwater (1-5)	1
Surcharge (Upper Beds Equal = 0, U.B. Weaker = -5)	0

COMMENTS:

Mine.....Western US
Location.....7 Left, 61 m (200 ft) outby XC-25
Exposure Type..Gate road roof X-section diagram
Name.....B. Wuest
Date.....10/15/93
Ground Support.1.8-m (6-ft) resin grouted bolts
" " .
" " .
Other Comments.Bone band pinched out
" " .Carbon. mudstone bands thinning
" " .

CMRR = 82 *

INDIVIDUAL DISCONTINUITY RATINGS:

Unit 1 IDRa = 70	Unit 2 IDRa =No data	Unit 3 IDRa =No data
" IDRb =No data	" IDRb =No data	" IDRb =No data
" IDRc =No data	" IDRc =No data	" IDRc =No data
" IDRd =No data	" IDRd =No data	" IDRd =No data
Unit 4 IDRa =No data	Unit 5 IDRa =No data	Unit 6 IDRa =No data
" IDRb =No data	" IDRb =No data	" IDRb =No data
" IDRc =No data	" IDRc =No data	" IDRc =No data
" IDRd =No data	" IDRd =No data	" IDRd =No data

UNIT RATINGS:

IDR 1 (lowest) = 70	IDR 2 (lowest) =No data	IDR 3 (lowest) =No data
MDA 1 = 0	MDA 2 =No data	MDA 3 =No data
US 1 = 15	US 2 =No data	US 3 =No data
MS 1 = -3	MS 2 =No data	MS 3 =No data
Unit Rating 1 = 82	Unit Rating 2 =No data	Unit Rating 3 =No data
IDR 4 (lowest) =No data	IDR 5 (lowest) =No data	IDR 6 (lowest) =No data
MDA 4 =No data	MDA 5 =No data	MDA 6 =No data
US 4 =No data	US 5 =No data	US 6 =No data
MS 4 =No data	MS 5 =No data	MS 6 =No data
Unit Rating 4 =No data	Unit Rating 5 =No data	Unit Rating 6 =No data

CMRR SUMMARY

COAL MINE ROOF RATING:

	Unit Rating		Bolted Thickness		
UR 1	82	X	6	=	492
UR 2	No data	X	No data	=	No data
UR 3	No data	X	No data	=	No data
UR 4	No data	X	No data	=	No data
UR 5	No data	X	No data	=	No data
UR 6	No data	X	No data	=	No data
Sum		=	6		492

Weighted Average of the Unit Ratings = 82

RRW =	82
Strong Bed Adjustment =	0
Bed Contact Adjustment =	0
Groundwater Adjustment =	0
Surcharge Adjustment =	0
CMRR =	82

Figure C-2.—Mining information from 61 m (200 ft) outby crosscut 25. *A*, Page 1 with field data; *B*, page 2 with additional field data and CMRR summary.

A

XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX
XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX

	UNIT					UNIT DISCONTINUITIES						
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity	Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
#6						a.						
						b.						
						c.						
						d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#5						a.						
						b.						
						c.						
						d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#4						a.						
						b.						
						c.						
						d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#3						a.						
						b.						
						c.						
						d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#2	0.8		Sandstone	2	1	a.	Intact rock	1	3			
						b.						
						c.						
						d.						
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX	XXXXXX	XXXXXXX
#1	5.2		Mudstone	3	2	a.	Bedding	1	2	3	2	
						b.						
						c.						
						d.						
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity	Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
	UNIT					UNIT DISCONTINUITIES						

XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXX
XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXX

B

ADDITIONAL ROOF CHARACTERISTICS:

Length Unit of Measure (Meters = 1, Feet = 2)	2
Thickness of Unit 6 Within the Bolted Interval	
" " " 5 " " " "	
" " " 4 " " " "	
" " " 3 " " " "	
" " " 2 " " " "	0.8
" " " 1 " " " "	5.2
Number of Unit Contacts of Significant Weakness Within the Bolted Interval	1
Groundwater (1-5)	1
Surcharge (Upper Beds Equal = 0, U.B. Weaker = -5)	0

COMMENTS:

Mine.....Western US
Location.....7 Left, 122 m (400 ft) outby XC-25
Exposure Type..Gate road foot X-section diagram
Name.....B. Wuest
Date.....10/15/93
Ground Support.1.8-m (6-ft) resin grouted bolts
" " .Wire mesh
" " .Steel pans
Other Comments.Bone band pinched out
" " .Carbon, mudstone bands thinning
" " .

****CMRR = 81 ****

INDIVIDUAL DISCONTINUITY RATINGS:

Unit 1 IDRa = 70
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 2 IDRa = 70
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 3 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 4 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 5 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 6 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

UNIT RATINGS:

IDR 1 (lowest) = 70
MDA 1 = 0
US 1 = 15
MS 1 = -3
Unit Rating 1 = 82

IDR 2 (lowest) = 70
MDA 2 = 0
US 2 = 22
MS 2 = 0
Unit Rating 2 = 92

IDR 3 (lowest) =No data
MDA 3 =No data
US 3 =No data
MS 3 =No data
Unit Rating 3 =No data

IDR 4 (lowest) =No data
MDA 4 =No data
US 4 =No data
MS 4 =No data
Unit Rating 4 =No data

IDR 5 (lowest) =No data
MDA 5 =No data
US 5 =No data
MS 5 =No data
Unit Rating 5 =No data

IDR 6 (lowest) =No data
MDA 6 =No data
US 6 =No data
MS 6 =No data
Unit Rating 6 =No data

CMRR SUMMARY

COAL MINE ROOF RATING:

	Unit Rating		Bolted Thickness		
UR 1	82	X	5.2	= 426.4	
UR 2	92	X	0.8	= 73.6	
UR 3	No data	X	No data	=No data	
UR 4	No data	X	No data	=No data	
UR 5	No data	X	No data	=No data	
UR 6	No data	X	No data	=No data	
Sum		=	6	500	

Weighted Average of the Unit Ratings = 83

RRW =	83
Strong Bed Adjustment =	0
Bed Contact Adjustment =	-2
Groundwater Adjustment =	0
Surcharge Adjustment =	0
CMRR =	81

Figure C-3.—Mining information from 122 m (400 ft) outby crosscut 25. *A*, Page 1 with field data; *B*, page 2 with additional field data and CMRR summary.

A

XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX
XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX

	UNIT					UNIT DISCONTINUITIES							
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
#6						a. b. c. d.				-			
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#5						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#4						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#3	4.5		Sandstone	2	1	a. b. c. d.	Intact rock	1	3				
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#2	0.5		Mudstone	5	2	a. b. c. d.	Bedding Slickenside	4 4	3 2	5 4	3 3		
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#1	1		Carbon. mudstone	5	3	a. b. c. d.	Bedding Slickenside	4 4	3 2	5 4	3 3		
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
	UNIT					UNIT DISCONTINUITIES							

XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXX
XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXX

B

ADDITIONAL ROOF CHARACTERISTICS:

Length Unit of Measure (Meters = 1, Feet = 2)	2
Thickness of Unit 6 Within the Bolted Interval	
" " " 5 " " " "	
" " " 4 " " " "	
" " " 3 " " " "	4.5
" " " 2 " " " "	0.5
" " " 1 " " " "	1
Number of Unit Contacts of Significant Weakness Within the Bolted Interval	2
Groundwater (1-5)	1
Surcharge (Upper Beds Equal = 0, U.B. Weaker = -5)	0

COMMENTS:

Mine.....Western US
Location.....7 Left, 176 m (575 ft) outby XC-25
Exposure Type..Gate road roof X-section diagram
Name.....B. Wuest
Date.....10/15/93
Ground Support.1.8-m (6-ft) resin grouted bolts
" " .Wire mesh
" " .Steel pans
Other Comments.Bone band thinning
" " .Carbon. mudstone bands thinning
" " .

****CMRR = 85 ****

INDIVIDUAL DISCONTINUITY RATINGS:

Unit 1 IDRa = 19	Unit 2 IDRa = 19	Unit 3 IDRa = 70
" IDRb = 23	" IDRb = 23	" IDRb =No data
" IDRc =No data	" IDRc =No data	" IDRc =No data
" IDRd =No data	" IDRd =No data	" IDRd =No data
Unit 4 IDRa =No data	Unit 5 IDRa =No data	Unit 6 IDRa =No data
" IDRb =No data	" IDRb =No data	" IDRb =No data
" IDRc =No data	" IDRc =No data	" IDRc =No data
" IDRd =No data	" IDRd =No data	" IDRd =No data

UNIT RATINGS:

IDR 1 (lowest) = 19	IDR 2 (lowest) = 19	IDR 3 (lowest) = 70
MDA 1 = -5	MDA 2 = -5	MDA 3 = 0
US 1 = 5	US 2 = 5	US 3 = 22
MS 1 = -10	MS 2 = -3	MS 3 = 0
Unit Rating 1 = 9	Unit Rating 2 = 16	Unit Rating 3 = 92
IDR 4 (lowest) =No data	IDR 5 (lowest) =No data	IDR 6 (lowest) =No data
MDA 4 =No data	MDA 5 =No data	MDA 6 =No data
US 4 =No data	US 5 =No data	US 6 =No data
MS 4 =No data	MS 5 =No data	MS 6 =No data
Unit Rating 4 =No data	Unit Rating 5 =No data	Unit Rating 6 =No data

CMRR SUMMARY

COAL MINE ROOF RATING:

	Unit Rating		Bolted Thickness		
UR 1	9	X	1	=	9
UR 2	16	X	0.5	=	8
UR 3	92	X	4.5	=	414
UR 4	No data	X	No data	=	No data
UR 5	No data	X	No data	=	No data
UR 6	No data	X	No data	=	No data
Sum		=	6		431

Weighted Average of the Unit Ratings = 72

RRW =	72
Strong Bed Adjustment =	15
Bed Contact Adjustment =	-2
Groundwater Adjustment =	0
Surcharge Adjustment =	0
CMRR =	85

Figure C-4.—Mining information from 176 m (575 ft) outby crosscut 25. *A*, Page 1 with field data; *B*, page 2 with additional field data and CMRR summary.

A

XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX
XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX

	UNIT					UNIT DISCONTINUITIES							
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity	Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
#6						a. b. c. d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#5						a. b. c. d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#4						a. b. c. d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#3						a. b. c. d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#2						a. b. c. d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#1	6		Sandstone	2	1	a. b. c. d.	Intact rock	1	3			
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity	Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
	UNIT					UNIT DISCONTINUITIES						

XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXXX
XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXXX

B

ADDITIONAL ROOF CHARACTERISTICS:

Length Unit of Measure (Meters = 1, Feet = 2)..... = 2
Thickness of Unit 6 Within the Bolted Interval..... =
" " " 5 " " " " ..... =
" " " 4 " " " " ..... =
" " " 3 " " " " ..... =
" " " 2 " " " " ..... =
" " " 1 " " " " ..... = 6
Number of Unit Contacts of Significant Weakness Within the Bolted Interval..... = 0
Groundwater (1-5)..... = 1
Surcharge (Upper Beds Equal = 0, U.B. Weaker = -5)..... = 0

COMMENTS:
Mine.....Western US
Location.....7 Left, 244 m (800 ft) outby XC-25
Exposure Type..Date Road Foot X-section diagram
Name.....B. Wuest
Date.....10/15/93
Ground Support.1.8-m (6-ft) resin grouted bolts
" " .
" " .
Other Comments.Bone band thinning
" " Carbon, mudstone bands present
" " .

****CMRR = 92 ****

INDIVIDUAL DISCONTINUITY RATINGS:

Unit 1 IDRa = 70
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 2 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 3 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 4 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 5 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 6 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

UNIT RATINGS:

IDR 1 (lowest) = 70
MDA 1 = 0
US 1 = 22
MS 1 = 0
Unit Rating 1 = 92

IDR 2 (lowest) =No data
MDA 2 =No data
US 2 =No data
MS 2 =No data
Unit Rating 2 =No data

IDR 3 (lowest) =No data
MDA 3 =No data
US 3 =No data
MS 3 =No data
Unit Rating 3 =No data

IDR 4 (lowest) =No data
MDA 4 =No data
US 4 =No data
MS 4 =No data
Unit Rating 4 =No data

IDR 5 (lowest) =No data
MDA 5 =No data
US 5 =No data
MS 5 =No data
Unit Rating 5 =No data

IDR 6 (lowest) =No data
MDA 6 =No data
US 6 =No data
MS 6 =No data
Unit Rating 6 =No data

CMRR SUMMARY

COAL MINE ROOF RATING:

	Unit Rating		Bolted Thickness		
UR 1	92	X	6	=	552
UR 2	No data	X	No data	=	No data
UR 3	No data	X	No data	=	No data
UR 4	No data	X	No data	=	No data
UR 5	No data	X	No data	=	No data
UR 6	No data	X	No data	=	No data
Sum		=	6		552

Weighted Average of the Unit Ratings = 92

RRW = 92
Strong Bed Adjustment = 0
Bed Contact Adjustment = 0
Groundwater Adjustment = 0
Surcharge Adjustment = 0
CMRR = 92

Figure C-5.—Mining information from 244 m (800 ft) outby crosscut 25. *A*, Page 1 with field data; *B*, page 2 with additional field data and CMRR summary.

A

XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX
XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX

	UNIT					UNIT DISCONTINUITIES						
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity	Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
#6						a. b. c. d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#5						a. b. c. d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#4						a. b. c. d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#3						a. b. c. d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#2						a. b. c. d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#1	6		Sandstone	2	1	a. b. c. d.	Intact rock	1	3			
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity	Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
	UNIT					UNIT DISCONTINUITIES						

XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXXX
XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXXX

B

ADDITIONAL ROOF CHARACTERISTICS:

Length Unit of Measure (Meters = 1, Feet = 2)	2
Thickness of Unit 6 Within the Bolted Interval	
" " " 5 " " " "	
" " " 4 " " " "	
" " " 3 " " " "	
" " " 2 " " " "	
" " " 1 " " " "	6
Number of Unit Contacts of Significant Weakness Within the Bolted Interval	0
Groundwater (1-5)	1
Surcharge (Upper Beds Equal = 0, U.B. Weaker = -5)	0

COMMENTS:

Mine.....Western US
Location.....7 Left, 305m (1000ft) outby XC-25
Exposure Type..Gate road roof X-section diagram
Name.....B. Wuest
Date.....10/15/93
Ground Support.1.8-m (6-ft) resin grouted bolts
" " .
" " .
Other Comments.Bone band thinning
" " .Carbon. mudstone bands present
" " .

CMRR = 92 *

INDIVIDUAL DISCONTINUITY RATINGS:

Unit 1 IDRa = 70	Unit 2 IDRa =No data	Unit 3 IDRa =No data
" IDRb =No data	" IDRb =No data	" IDRb =No data
" IDRc =No data	" IDRc =No data	" IDRc =No data
" IDRd =No data	" IDRd =No data	" IDRd =No data
Unit 4 IDRa =No data	Unit 5 IDRa =No data	Unit 6 IDRa =No data
" IDRb =No data	" IDRb =No data	" IDRb =No data
" IDRc =No data	" IDRc =No data	" IDRc =No data
" IDRd =No data	" IDRd =No data	" IDRd =No data

UNIT RATINGS:

IDR 1 (lowest) = 70	IDR 2 (lowest) =No data	IDR 3 (lowest) =No data
MDA 1 = 0	MDA 2 =No data	MDA 3 =No data
US 1 = 22	US 2 =No data	US 3 =No data
MS 1 = 0	MS 2 =No data	MS 3 =No data
Unit Rating 1 = 92	Unit Rating 2 =No data	Unit Rating 3 =No data
IDR 4 (lowest) =No data	IDR 5 (lowest) =No data	IDR 6 (lowest) =No data
MDA 4 =No data	MDA 5 =No data	MDA 6 =No data
US 4 =No data	US 5 =No data	US 6 =No data
MS 4 =No data	MS 5 =No data	MS 6 =No data
Unit Rating 4 =No data	Unit Rating 5 =No data	Unit Rating 6 =No data

CMRR SUMMARY

COAL MINE ROOF RATING:

	Unit Rating		Bolted Thickness		
UR 1	92	X	6	=	552
UR 2	No data	X	No data	=	No data
UR 3	No data	X	No data	=	No data
UR 4	No data	X	No data	=	No data
UR 5	No data	X	No data	=	No data
UR 6	No data	X	No data	=	No data
Sum		=	6		552

Weighted Average of the Unit Ratings = 92

RRW =	92
Strong Bed Adjustment =	0
Bed Contact Adjustment =	0
Groundwater Adjustment =	0
Surcharge Adjustment =	0
CMRR =	92

Figure C-6.—Mining information from 305 m (1,000 ft) outby crosscut 25. *A*, Page 1 with field data; *B*, page 2 with additional field data and CMRR summary.

A

XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX
XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX

	UNIT					UNIT DISCONTINUITIES						
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity	Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
#6						a. b. c. d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#5						a. b. c. d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#4						a. b. c. d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#3						a. b. c. d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#2						a. b. c. d.						
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact			XXXXXXX		XXXXXX	XXXXXXX
#1	6		Sandstone	2	1	a. b. c. d.	Intact rock	1	3			
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity	Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
	UNIT					UNIT DISCONTINUITIES						

XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXXX
XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXXX

B

ADDITIONAL ROOF CHARACTERISTICS:

Length Unit of Measure (Meters = 1, Feet = 2)..... = 2
Thickness of Unit 6 Within the Bolted Interval..... =
" " " 5 " " " " ..... =
" " " 4 " " " " ..... =
" " " 3 " " " " ..... =
" " " 2 " " " " ..... =
" " " 1 " " " " ..... = 6
Number of Unit Contacts of Significant Weakness Within the Bolted Interval..... = 0
Groundwater (1-5)..... = 1
Surcharge (Upper Beds Equal = 0, U.B. Weaker = -5)..... = 0

COMMENTS:

Mine.....Western US
Location.....7 Left, 352m (1150ft) outby XC-25
Exposure Type..Gate road roof X-section diagram
Name.....B. Wuest
Date.....10/15/93
Ground Support.1.8-m (6-ft) combination bolts
" " .Wire mesh
" " .Steel pans
Other Comments.Bone band thinning
" " .Carbon. mudstone bands present
" " .

****CMRR = 92 ****

CMRR SUMMARY

INDIVIDUAL DISCONTINUITY RATINGS:

Unit 1 IDRa = 70
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 2 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 3 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 4 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 5 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 6 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

UNIT RATINGS:

IDR 1 (lowest) = 70
MDA 1 = 0
US 1 = 22
MS 1 = 0
Unit Rating 1 = 92

IDR 2 (lowest) =No data
MDA 2 =No data
US 2 =No data
MS 2 =No data
Unit Rating 2 =No data

IDR 3 (lowest) =No data
MDA 3 =No data
US 3 =No data
MS 3 =No data
Unit Rating 3 =No data

IDR 4 (lowest) =No data
MDA 4 =No data
US 4 =No data
MS 4 =No data
Unit Rating 4 =No data

IDR 5 (lowest) =No data
MDA 5 =No data
US 5 =No data
MS 5 =No data
Unit Rating 5 =No data

IDR 6 (lowest) =No data
MDA 6 =No data
US 6 =No data
MS 6 =No data
Unit Rating 6 =No data

COAL MINE ROOF RATING:

	Unit Rating		Bolted Thickness		
UR 1	92	X	6	=	552
UR 2	No data	X	No data	=	No data
UR 3	No data	X	No data	=	No data
UR 4	No data	X	No data	=	No data
UR 5	No data	X	No data	=	No data
UR 6	No data	X	No data	=	No data
Sum		=	6		552

Weighted Average of the Unit Ratings = 92

RRW = 92
Strong Bed Adjustment = 0
Bed Contact Adjustment = 0
Groundwater Adjustment = 0
Surcharge Adjustment = 0
CMRR = 92

Figure C-7.—Mining information from 352 m (1,150 ft) outby crosscut 25. *A*, Page 1 with field data; *B*, page 2 with additional field data and CMRR summary.

A

XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX
XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX

	UNIT						UNIT DISCONTINUITIES						
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
#6						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#5	2.5		Sandstone	2	1	a. b. c. d.	Intact rock	1	3				
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#4	1		Mudstone	5	1	a. b. c. d.	Bedding Slickenside	4 4	3 2	5 4	3 3		
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#3	0.5		Sandstone	2	1	a. b. c. d.	Intact rock	1	3				
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#2	1.5		Mudstone	5	2	a. b. c. d.	Bedding Slickenside	4 4	3 2	5 4	3 3		
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#1	0.5		Carbon. mudstone	5	3	a. b. c. d.	Bedding Slickenside	4 4	3 2	5 4	3 3		
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
	UNIT						UNIT DISCONTINUITIES						

XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXXX
XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXXX

B

ADDITIONAL ROOF CHARACTERISTICS:

Length Unit of Measure (Meters = 1, Feet = 2)..... = 2
Thickness of Unit 6 Within the Bolted Interval..... =
" " " 5 " " " " ..... = 2.5
" " " 4 " " " " ..... = 1
" " " 3 " " " " ..... = 0.5
" " " 2 " " " " ..... = 1.5
" " " 1 " " " " ..... = 0.5
Number of Unit Contacts of Significant Weakness Within the Bolted Interval..... = 4
Groundwater (1-5)..... = 1
Surcharge (Upper Beds Equal = 0, U.B. Weaker = -5)..... = -5

COMMENTS:

Mine.....Western US
Location.....7 Left, 436m (1425ft) outby XC-25
Exposure Type..Gate Road Foot X-section diagram
Name.....B. Wuest
Date.....10/15/93
Ground Support.1.8 m (6-ft) combination bolts
" " .Wire mesh
" " .Steel pans
Other Comments.Bone band pinched out
" " .Carbon. mudstone bands present
" " .

****CMRR = 61 ****

INDIVIDUAL DISCONTINUITY RATINGS:

Unit 1 IDRa = 19
" IDRb = 23
" IDRc =No data
" IDRd =No data

Unit 2 IDRa = 19
" IDRb = 23
" IDRc =No data
" IDRd =No data

Unit 3 IDRa = 70
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 4 IDRa = 19
" IDRb = 23
" IDRc =No data
" IDRd =No data

Unit 5 IDRa = 70
" IDRb =No data
" IDRc =No data
" IDRd =No data

Unit 6 IDRa =No data
" IDRb =No data
" IDRc =No data
" IDRd =No data

UNIT RATINGS:

IDR 1 (lowest) = 19
MDA 1 = -5
US 1 = 5
MS 1 = -10
Unit Rating 1 = 9

IDR 2 (lowest) = 19
MDA 2 = -5
US 2 = 5
MS 2 = -3
Unit Rating 2 = 16

IDR 3 (lowest) = 70
MDA 3 = 0
US 3 = 22
MS 3 = 0
Unit Rating 3 = 92

IDR 4 (lowest) = 19
MDA 4 = -5
US 4 = 5
MS 4 = 0
Unit Rating 4 = 19

IDR 5 (lowest) = 70
MDA 5 = 0
US 5 = 22
MS 5 = 0
Unit Rating 5 = 92

IDR 6 (lowest) =No data
MDA 6 =No data
US 6 =No data
MS 6 =No data
Unit Rating 6 =No data

CMRR SUMMARY

COAL MINE ROOF RATING:

	Unit Rating		Bolted Thickness		
UR 1	9	X	0.5	=	4.5
UR 2	16	X	1.5	=	24
UR 3	92	X	0.5	=	46
UR 4	19	X	1	=	19
UR 5	92	X	2.5	=	230
UR 6	No data	X	No data	=	No data
Sum		=	6		323.5

Weighted Average of the Unit Ratings = 54

RRW = 54
Strong Bed Adjustment = 16
Bed Contact Adjustment = -4
Groundwater Adjustment = 0
Surcharge Adjustment = -5
CMRR = 61

Figure C-8.—Mining information from 436 m (1,425 ft) outby crosscut 25. *A*, Page 1 with field data; *B*, page 2 with additional field data and CMRR summary.

A

XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX
XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX

	UNIT					UNIT DISCONTINUITIES							
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
#6						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#5	2		Sandstone	2	1	a. b. c. d.	Intact rock	1	3				
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#4	1		Mudstone	5	1	a. b. c. d.	Bedding Slickenside	4 4	3 2	5 4	3 3		
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#3	0.5		Sandstone	2	1	a. b. c. d.	Intact rock	1	3				
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#2	2		Mudstone	5	2	a. b. c. d.	Bedding Slickenside	4 4	3 2	5 4	3 3		
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#1	0.5		Carbon. mudstone	5	3	a. b. c. d.	Bedding Slickenside	4 4	3 2	5 4	3 3		
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
	UNIT						UNIT DISCONTINUITIES						

XXXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXX
XXXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXX

B

ADDITIONAL ROOF CHARACTERISTICS:

Length Unit of Measure (Meters = 1, Feet = 2)	2
Thickness of Unit 6 Within the Bolted Interval	
" " " 5 " " " "	2
" " " 4 " " " "	1
" " " 3 " " " "	0.5
" " " 2 " " " "	2
" " " 1 " " " "	0.5
Number of Unit Contacts of Significant Weakness Within the Bolted Interval	4
Groundwater (1-5)	1
Surcharge (Upper Beds Equal = 0, U.B. Weaker = -5)	-5

COMMENTS:

Mine.....Western US
Location.....7 Left, 497m (1625ft) outby XC-25
Exposure Type..Gate road roof X-section diagram
Name.....W. Wuest
Date.....10/15/93
Ground Support.1.8-m (6-ft) combination bolts
" " .Wire mesh
" " .Steel pans
Other Comments.Bone band pinched out
" " .Carbon. mudstone bands present
" " .

****CMRR = 51 ****

INDIVIDUAL DISCONTINUITY RATINGS:

Unit 1 IDRa = 19	Unit 2 IDRa = 19	Unit 3 IDRa = 70
" IDRb = 23	" IDRb = 23	" IDRb =No data
" IDRc =No data	" IDRc =No data	" IDRc =No data
" IDRd =No data	" IDRd =No data	" IDRd =No data
Unit 4 IDRa = 19	Unit 5 IDRa = 70	Unit 6 IDRa =No data
" IDRb = 23	" IDRb =No data	" IDRb =No data
" IDRc =No data	" IDRc =No data	" IDRc =No data
" IDRd =No data	" IDRd =No data	" IDRd =No data

UNIT RATINGS:

IDR 1 (lowest) = 19	IDR 2 (lowest) = 19	IDR 3 (lowest) = 70
MDA 1 = -5	MDA 2 = -5	MDA 3 = 0
US 1 = 5	US 2 = 5	US 3 = 22
MS 1 = -10	MS 2 = -3	MS 3 = 0
Unit Rating 1 = 9	Unit Rating 2 = 16	Unit Rating 3 = 92
IDR 4 (lowest) = 19	IDR 5 (lowest) = 70	IDR 6 (lowest) =No data
MDA 4 = -5	MDA 5 = 0	MDA 6 =No data
US 4 = 5	US 5 = 22	US 6 =No data
MS 4 = 0	MS 5 = 0	MS 6 =No data
Unit Rating 4 = 19	Unit Rating 5 = 92	Unit Rating 6 =No data

CMRR SUMMARY

COAL MINE ROOF RATING:

	Unit Rating		Bolted Thickness		
UR 1	9	X	0.5	=	4.5
UR 2	16	X	2	=	32
UR 3	92	X	0.5	=	46
UR 4	19	X	1	=	19
UR 5	92	X	2	=	184
UR 6	No data	X	No data	=	No data
Sum		=	6		285.5

RRW =	48
Strong Bed Adjustment =	12
Bed Contact Adjustment =	-4
Groundwater Adjustment =	0
Surcharge Adjustment =	-5
CMRR =	51

Weighted Average of the Unit Ratings = 48

Figure C-9.—Mining information from 497 m (1,625 ft) outby crosscut 25. *A*, Page 1 with field data; *B*, page 2 with additional field data and CMRR summary.

A

XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX
XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX

	UNIT						UNIT DISCONTINUITIES							
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
#6						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#5						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#4						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#3						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#2	1		Mudstone	3	1	a. b. c. d.	Bedding	1	2	3	2		
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#1	5		Sandstone	2	1	a. b. c. d.	Intact rock	1	3				
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
	UNIT						UNIT DISCONTINUITIES						

XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXXX
XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXXX

B

ADDITIONAL ROOF CHARACTERISTICS:

Length Unit of Measure (Meters = 1, Feet = 2)	2
Thickness of Unit 6 Within the Bolted Interval	
" " " 5 " " " "	
" " " 4 " " " "	
" " " 3 " " " "	
" " " 2 " " " "	1
" " " 1 " " " "	5
Number of Unit Contacts of Significant Weakness Within the Bolted Interval	1
Groundwater (1-5)	1
Surcharge (Upper Beds Equal = 0, U.B. Weaker = -5)	-5

COMMENTS:

Mine.....Western US
Location.....7 Left, 566m (1850ft) outby XC-25
Exposure Type..Gate road roof X-section diagram
Name.....B. Wuest
Date.....10/15/93
Ground Support.1.8-m (6-ft) combination bolts
" " .Wire mesh
" " .Steel pans
Other Comments.Bone band present
" " .Carbon, mudstone bands present
" "

****CMRR = 84 ****

INDIVIDUAL DISCONTINUITY RATINGS:

Unit 1 IDRa = 70	Unit 2 IDRa = 70	Unit 3 IDRa =No data
" IDRb =No data	" IDRb =No data	" IDRb =No data
" IDRc =No data	" IDRc =No data	" IDRc =No data
" IDRd =No data	" IDRd =No data	" IDRd =No data
Unit 4 IDRa =No data	Unit 5 IDRa =No data	Unit 6 IDRa =No data
" IDRb =No data	" IDRb =No data	" IDRb =No data
" IDRc =No data	" IDRc =No data	" IDRc =No data
" IDRd =No data	" IDRd =No data	" IDRd =No data

CMRR SUMMARY

UNIT RATINGS:

IDR 1 (lowest) = 70	IDR 2 (lowest) = 70	IDR 3 (lowest) =No data
MDA 1 = 0	MDA 2 = 0	MDA 3 =No data
US 1 = 22	US 2 = 15	US 3 =No data
MS 1 = 0	MS 2 = 0	MS 3 =No data
Unit Rating 1 = 92	Unit Rating 2 = 85	Unit Rating 3 =No data
IDR 4 (lowest) =No data	IDR 5 (lowest) =No data	IDR 6 (lowest) =No data
MDA 4 =No data	MDA 5 =No data	MDA 6 =No data
US 4 =No data	US 5 =No data	US 6 =No data
MS 4 =No data	MS 5 =No data	MS 6 =No data
Unit Rating 4 =No data	Unit Rating 5 =No data	Unit Rating 6 =No data

COAL MINE ROOF RATING:

	Unit Rating		Bolted Thickness		
UR 1	92	X	5	=	460
UR 2	85	X	1	=	85
UR 3	No data	X	No data	=	No data
UR 4	No data	X	No data	=	No data
UR 5	No data	X	No data	=	No data
UR 6	No data	X	No data	=	No data
Sum		=	6		545

Weighted Average of the Unit Ratings = 91

RRW =	91
Strong Bed Adjustment =	0
Bed Contact Adjustment =	-2
Groundwater Adjustment =	0
Surcharge Adjustment =	-5
CMRR =	84

Figure C-10.—Mining information from 566 m (1,850 ft) outby crosscut 25. *A*, Page 1 with field data; *B*, page 2 with additional field data and CMRR summary.

A

XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX
XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX

	UNIT					UNIT DISCONTINUITIES							
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
#6						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#5						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#4						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#3	4.5		Sandstone	2	1	a. b. c. d.	Intact rock	1	3				
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#2	1		Mudstone	5	2	a. b. c. d.	Bedding Slickenside	4 4	3 2	5 4	3 3		
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#1	0.5		Carbon. mudstone	5	3	a. b. c. d.	Bedding Slickenside	4 4	3 2	5 4	3 3		
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
	UNIT					UNIT DISCONTINUITIES							

XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXX
XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXXX

B

ADDITIONAL ROOF CHARACTERISTICS:

Length Unit of Measure (Meters = 1, Feet = 2)	= 2
Thickness of Unit 6 Within the Bolted Interval	=
" " " 5 " " " "	=
" " " 4 " " " "	=
" " " 3 " " " "	= 4.5
" " " 2 " " " "	= 1
" " " 1 " " " "	= 0.5
Number of Unit Contacts of Significant Weakness Within the Bolted Interval	= 2
Groundwater (1-5)	= 1
Surcharge (Upper Beds Equal = 0, U.B. Weaker = -5)	= -5

COMMENTS:

Mine.....Western US
Location.....7 Left, 610m (2000ft) outby XC-25
Exposure Type..Gate road roof X-section diagram
Name.....B. Wuest
Date.....10/15/93
Ground Support.1.8-m (6-ft) combination bolts
" " .Wire mesh
" " .Steel pans
Other Comments.Bone band present
" " .Carbon. mudstone bands present
" " .

****CMRR = 80 ****

INDIVIDUAL DISCONTINUITY RATINGS:

Unit 1 IDRa = 19	Unit 2 IDRa = 19	Unit 3 IDRa = 70
" IDRb = 23	" IDRb = 23	" IDRb =No data
" IDRc =No data	" IDRc =No data	" IDRc =No data
" IDRd =No data	" IDRd =No data	" IDRd =No data
Unit 4 IDRa =No data	Unit 5 IDRa =No data	Unit 6 IDRa =No data
" IDRb =No data	" IDRb =No data	" IDRb =No data
" IDRc =No data	" IDRc =No data	" IDRc =No data
" IDRd =No data	" IDRd =No data	" IDRd =No data

UNIT RATINGS:

IDR 1 (lowest) = 19	IDR 2 (lowest) = 19	IDR 3 (lowest) = 70
MDA 1 = -5	MDA 2 = -5	MDA 3 = 0
US 1 = 5	US 2 = 5	US 3 = 22
MS 1 = -10	MS 2 = -3	MS 3 = 0
Unit Rating 1 = 9	Unit Rating 2 = 16	Unit Rating 3 = 92
IDR 4 (lowest) =No data	IDR 5 (lowest) =No data	IDR 6 (lowest) =No data
MDA 4 =No data	MDA 5 =No data	MDA 6 =No data
US 4 =No data	US 5 =No data	US 6 =No data
MS 4 =No data	MS 5 =No data	MS 6 =No data
Unit Rating 4 =No data	Unit Rating 5 =No data	Unit Rating 6 =No data

CMRR SUMMARY

	Unit Rating		Bolted Thickness		
UR 1	9	X	0.5	=	4.5
UR 2	16	X	1	=	16
UR 3	92	X	4.5	=	414
UR 4	No data	X	No data	=	No data
UR 5	No data	X	No data	=	No data
UR 6	No data	X	No data	=	No data
Sum		=	6		434.5

Weighted Average of the Unit Ratings = 72

RRW =	72
Strong Bed Adjustment =	15
Bed Contact Adjustment =	-2
Groundwater Adjustment =	0
Surcharge Adjustment =	-5
CMRR =	80

Figure C-11.—Mining information from 610 m (2,000 ft) outby crosscut 25. *A*, Page 1 with field data; *B*, page 2 with additional field data and CMRR summary.

A

XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX
XXXXXXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXX TOP OF EXPOSURE XXXXXXXXXXX

	UNIT					UNIT DISCONTINUITIES							
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
#6						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#5						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#4						a. b. c. d.							
	Contact	XXXXX		XXXXXXXX	XXXXXXXXXX	Contact				XXXXXXX		XXXXXX	XXXXXXX
#3	2		Sandstone	2	1	a. b. c. d.	Intact rock	1	3				
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#2	3.5		Mudstone	3	2	a. b. c. d.	Bedding	1	2	3	2		
	Contact	XXXXX	Sharp	XXXXXXXX	XXXXXXXXXX	Contact	Sharp			XXXXXXX		XXXXXX	XXXXXXX
#1	0.5		Carbon. mudstone	5	3	a. b. c. d.	Bedding Slickenside	4 4	3 2	5 4	3 3		
	Thickness (m or ft)	Strip Log	Description	Strength	Moisture Sensitivity		Description	Cohesion	Rough-ness	Spacing	Persistence Lat./Vert.	Strike Orien.	Dip Orien.
	UNIT					UNIT DISCONTINUITIES							

XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXX
XXXXXXXXXXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXX BOTTOM OF EXPOSURE XXXXXXXXXXXXXXX

B

```
ADDITIONAL ROOF CHARACTERISTICS:
================================
Length Unit of Measure (Meters = 1, Feet = 2)..... =      2
Thickness of Unit 6 Within the Bolted Interval..... =
    "    "  "  5  "    "   "      "    ..... =
    "    "  "  4  "    "   "      "    ..... =
    "    "  "  3  "    "   "      "    ..... =      2
    "    "  "  2  "    "   "      "    ..... =    3.5
    "    "  "  1  "    "   "      "    ..... =    0.5
Number of Unit Contacts of Significant Weakness Within the
  Bolted Interval..... =      2
Groundwater (1-5)..... =      1
Surcharge (Upper Beds Equal = 0, U.B. Weaker = -5)..... =

COMMENTS:
=========
Mine.....Western US
Location.....7 Left, 671m (2200ft) outby XC-25
Exposure Type..Gate Road Roof X-section Diagram
Name.....B. Wuest
Date.....10/15/93
Ground Support.1.8-m (6-ft) combination bolts
    "       "  .Wire mesh
    "       "  .Steel pans
Other Comments.Bone band present
    "       "  .Carbon. mudstone bands present
    "       "  -

****CMRR = 79 ****

CMRR SUMMARY
============

INDIVIDUAL DISCONTINUITY RATINGS:
---------------------------------

Unit 1 IDRa =      19          Unit 2 IDRa =      70          Unit 3 IDRa =      70
  "    IDRb =      23            "    IDRb =No data           "    IDRb =No data
  "    IDRc =No data              "    IDRc =No data           "    IDRc =No data
  "    IDRd =No data              "    IDRd =No data           "    IDRd =No data

Unit 4 IDRa =No data          Unit 5 IDRa =No data          Unit 6 IDRa =No data
  "    IDRb =No data            "    IDRb =No data           "    IDRb =No data
  "    IDRc =No data            "    IDRc =No data           "    IDRc =No data
  "    IDRd =No data            "    IDRd =No data           "    IDRd =No data

UNIT RATINGS:
-------------
IDR 1 (lowest) =      19     IDR 2 (lowest) =      70     IDR 3 (lowest) =      70
         MDA 1 =      -5              MDA 2 =       0              MDA 3 =       0
         US 1 =       5               US 2 =      15              US 3 =      22
         MS 1 =     -10               MS 2 =      -3              MS 3 =       0
                ========                        ========                      =======
Unit Rating 1 =       9     Unit Rating 2 =      82     Unit Rating 3 =      92

IDR 4 (lowest) =No data     IDR 5 (lowest) =No data     IDR 6 (lowest) =No data
         MDA 4 =No data              MDA 5 =No data              MDA 6 =No data
         US 4 =No data               US 5 =No data               US 6 =No data
         MS 4 =No data               MS 5 =No data               MS 6 =No data
                ==========                      ========                      =======
Unit Rating 4 =No data     Unit Rating 5 =No data     Unit Rating 6 =No data

COAL MINE ROOF RATING:
----------------------
                  Unit          Bolted
                  Rating        Thickness
                  ------        ---------
            UR 1        9 X           0.5 =     4.5      RRW =      79
            UR 2       82 X           3.5 =     287      Strong Bed Adjustment =       2
            UR 3       92 X             2 =     184      Bed Contact Adjustment =      -2
            UR 4No data   X       No data   =No data      Groundwater Adjustment =       0
            UR 5No data   X       No data   =No data        Surcharge Adjustment =
            UR 6No data   X       No data   =No data                             ==========
                        ========= ========= =========      CMRR =      79
                  Sum   =                 6     475.5

          Weighted Average of the Unit Ratings =      79
```

Figure C-12.—Mining information from 671 m (2,200 ft) outby crosscut 25. *A*, Page 1 with field data; *B*, page 2 with additional field data and CMRR summary.