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Coal Mine Roof Rating (CMRR): A Practical Rock Mass Classification for Coal Mines

By Gregory M. Molinda and Christopher Mark



United States Department of the Interior



Bureau of Mines

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Cover Photo: A U.S. Bureau of Mines geologist collects field data to calculate the Coal Mine Roof Rating (CMRR). (Photo: David K. Ingram, Pittsburgh Research Center, U.S. Bureau of Mines)

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Bruce Babbitt, Secretary

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cm	centimeter	min	minute
ft	foot	mm	millimeter
gal/min	gallon per minute	MPa	megapascal
h	hour	psi	pound (force) per square inch
in	inch	%	percent
L/min	liter per minute	°	degree
m	meter		

COAL MINE ROOF RATING (CMRR): A PRACTICAL ROCK MASS CLASSIFICATION FOR COAL MINES

By Gregory M. Molinda¹ and Christopher Mark²

ABSTRACT

The Coal Mine Roof Rating (CMRR) was developed by the U.S. Bureau of Mines as an engineering tool to quantify descriptive geologic information for use in coal mine design and roof support selection. The CMRR system combines the results of many years of geologic ground control research with worldwide experience with rock mass classification systems. Like other classification systems, the CMRR begins with the premise that the structural competence of mine roof rock is determined primarily by the discontinuities that weaken the rock fabric. The CMRR makes four unique contributions: (1) It is specifically designed for bedded coal measure rocks, (2) it concentrates on the bolted interval and its ability to form a stable mine structure, (3) it is applicable to all U.S. coal seams, and (4) it provides a methodology for data collection. Using only simple field tests and observations, the CMRR can be calculated from roof falls, overcasts, and highwall exposures. This report includes a discussion of the principles, input parameters, and method of the CMRR. It also includes CMRR data from all of the major U.S. coal basins and an analysis of the data in relation to current applications.

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INTRODUCTION

The U.S. Bureau of Mines (USBM), under its health and safety research program, has been actively studying coal measure roof strata for ground control. Much has been learned about the behavior of roof rock under many different mining conditions (4, 8, 11-12, 15-18, 20, 22-27, 29, 34, 40).³ A significant portion of this research effort has been examining the effects of geology on mine roof stability, since coal mine operators often cite poor geology as their primary ground control problem. Numerous other factors, including roof span, artificial support, and in situ stresses, influence roof stability, but inherent structural competence of the rock mass is of primary importance. Currently, roof bolt selection and design revolve around a trial-and-error process, with mine operators reacting to adverse roof conditions by changing support type or increasing support density until stability is achieved. Improved roof bolt design methods will require an ability to quantify the inherent structural competence of the mine roof.

The ability to quantify roof rock quality will be helpful in many other facets of ground control design. Recent research has demonstrated that the selection of a stability factor for longwall coal pillars should be based on an evaluation of mine roof quality (24). Another example is the design of intersection spans, which is often based on equipment needs and transportation. The practice of shaving the corners of the pillars (and thus widening the span) may have disastrous consequences for a less competent roof rock, but little effect where the roof is very competent.

In the past, geotechnical evaluations of coal mine roof rock have been based largely on laboratory testing of rock properties, such as uniaxial compressive strength and direct shear. However, laboratory testing fails to consider the field-scale discontinuities, particularly bedding planes (28), that usually control the structural competence of the roof. For example, the uniaxial strength of a typical Pittsburgh coalbed stackrock is approximately 83 MPa (12,000 psi). Although strong uniaxially, the numerous mica-laden, carbonaceous bedding planes make the rock very weak and subject to delamination and shear. Control of this type of rock involves a full-column resin fixture to prevent shear.

Historically, accounts of mine roof geology have been highly descriptive and required interpretation for use in engineering design and support selection. The geologist at the mine typically describes the geologic conditions in the roof, then the engineer attempts to utilize those descriptions to design a roof support or reinforcement plan.

What is required is a bridge between geologic description and *quantitative* engineering description. Mine engineers need a system to compare roof conditions with those of others in the field and to compare the success of different roof support or pillar designs in conditions similar to those at their own mines.

The geologic research of the USBM, although understood and acknowledged by mine operators, has not been fully incorporated to date into day-to-day planning at many mines. Mine and support system design is still accomplished largely by trial and error. This bridge, however, has been crossed in other engineering disciplines. In civil engineering, rock mass classification systems have emerged as powerful, practical methods for utilizing geologic data in the design of tunnels and other underground excavations. The most widely known systems, such as the Rock Quality Designation (RQD) (9), Rock Mass Rating (RMR) (3), Unified Rock Classification System (URCS) (42), the Q system (1), and others (10, 32) have been used extensively throughout the world. These methods have been successful because they—

- Improve the geologic site evaluation,
- Provide a methodology to convert geologic data into engineering data, and
- Enable better communication between geologists and engineers (2).

Unfortunately, the civil engineering classification systems are not readily adaptable to coal mining because they do not provide for the layered geology and geologic structures typical of coal mine roof. Additionally, the dimensions and stability requirements of tunnels are often very different from those of mines.

Several attempts have been made to develop roof classification systems specific to coal mining. Appendix A summarizes these classifications, with brief descriptions of the approach taken. These are diverse, but none have been entirely satisfactory. Some use only drill core information and exclude the many geologic features that might be observed underground. The end product is seldom quantitative and requires considerable judgment to arrive at specific conclusions. Most importantly, most of these classifications were developed within small geographic areas and are generally intended to apply to only a few local classes of mine roof.

The USBM has developed the CMRR as a means to fulfill these needs where previous classification systems have been inadequate. It serves as a method for quantifying the structural competence of any coal mine roof sequence for ultimate use in roof support selection and coal pillar design (24, 30). The important roof parameters

³Italic numbers in parentheses refer to items in the list of references preceding the appendixes.

have been identified, their influence on roof strength has been quantified, and a calculation has been devised to combine these parameters into a single, usable value.

The principle of the CMRR is to evaluate the geotechnical, rather than the geologic, characteristics of the mine roof. Many times these two correspond, but the emphasis is on structurally weak or strong units instead of geologic divisions. This bridge between geology and engineering makes cumbersome lithologic description unnecessary, and emphasis is shifted to those things that weaken bedded coal measure rocks, such as bedding planes, slickensides, joints, laminations, etc. The CMRR evaluates the properties of roof discontinuities and how these properties combine to weaken the roof. As a result,

the geologic origin of a discontinuity is less important than its engineering characteristics.

The CMRR is intended to guide the evaluation of roof competence. It is impossible to consider all of the geologic associations that occur. Flexibility is encouraged in its application, and the workers' past experience in the roof sequence competence is important. For example, if a rock layer is known to be an important strong member of the roof, but is less than 15 cm (6 in), it should be considered as a separate unit. The exception is based on the workers' experience. The CMRR provides procedures for (1) the complete collection of data relevant to roof competence and (2) evaluation of the rock mass properties that affect roof competence.

COMPONENTS OF THE COAL MINE ROOF RATING (CMRR)

The purpose of the CMRR is to identify the lithologic factors that influence the structural competence of mine roof and weigh them according to their relative importance. The sum of these individual factors should correctly account for the structural competence of the bolted interval of the roof sequence, all other mining influences being equal. Following is a summary of the CMRR, with further details given in later sections of this report.

The CMRR employs the familiar format of Bieniawski's RMR, summing various individual ratings to obtain a final CMRR on a 0-100 scale (3). The CMRR is also designed so that the CMRR/unsupported span/standup time relationship is roughly comparable to the relationship determined for the RMR. Certain other features have been adapted from classification systems proposed by Moebis and Stateham (28), Williamson (42), Barton (1), Kester

and Chugh (21), Sickler (37), and the International Society for Rock Mechanics (5). Much of the field data used in the development of the CMRR were obtained during a nationwide study of ground control in longwall mines (24). Figure 1 shows the parameters composing the CMRR.

In developing the CMRR, several factors were considered. First, the collection of geotechnical data must be relatively simple and inexpensive. This would exclude time-consuming, expensive laboratory analysis, such as rock testing and petrography. However, if laboratory strength data are available, they may still be used to generate the roof rating. Second, the CMRR must be a *universal* system, i.e., applicable to *all* coal measure rocks, regardless of depositional environment, age, rank, or geographic location.

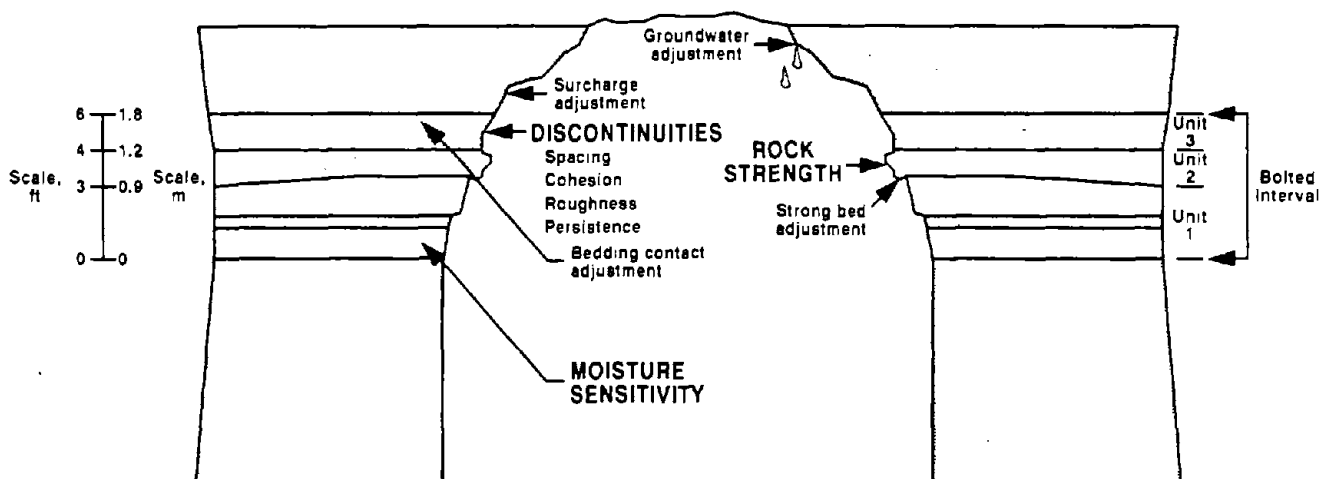


Figure 1.—Components of the USBM Coal Mine Roof Rating (CMRR).

Data gathering for the CMRR relies on observation and simple contact tests using a ball peen hammer, a 9-cm (3.5-in) mason chisel, a tape measure, and sample bags. All data can be recorded on a single data sheet. Of course, roof rocks must be exposed for the CMRR, and data sources include falls, overcasts, core, and highwalls.

Calculation of the CMRR is illustrated in figure 2. In the roof exposure to be rated, all of the visible rock is included in the data collection. The mine roof is first divided into structural units. A rating is then determined for each unit based primarily on an evaluation of the discontinuities and their characteristics. The compressive strength of the rock and its moisture sensitivity also figure into the unit ratings. Next, the CMRR is determined for the mine roof as a whole. The ratings of the units within the bolted interval are first combined into a thickness-weighted average. Then a series of roof adjustment factors is applied. The most important adjustment is the one for a strong bed, for it has been found that the structural competence of a bolted mine roof is largely determined by

its most competent member. All of these parameters combined form the final CMRR. A step-by-step process for field data collection and CMRR calculation is presented in appendix B.

UNIT RATINGS

Unit ratings are the building blocks of the CMRR. Units are defined as rock intervals with distinct structural characteristics. CMRR units are usually distinct lithologic types, but they are distinguished by geotechnical, not geological, characteristics. For example, interbedded coals and shales might be treated a single unit if they have similar geotechnical properties. Units must also be at least 15 cm (6 in) thick, because it is assumed that thinner units are unlikely to significantly affect the overall structural competence of the bolted roof. Factors entering into the determination of the unit rating are discussed in the following sections.

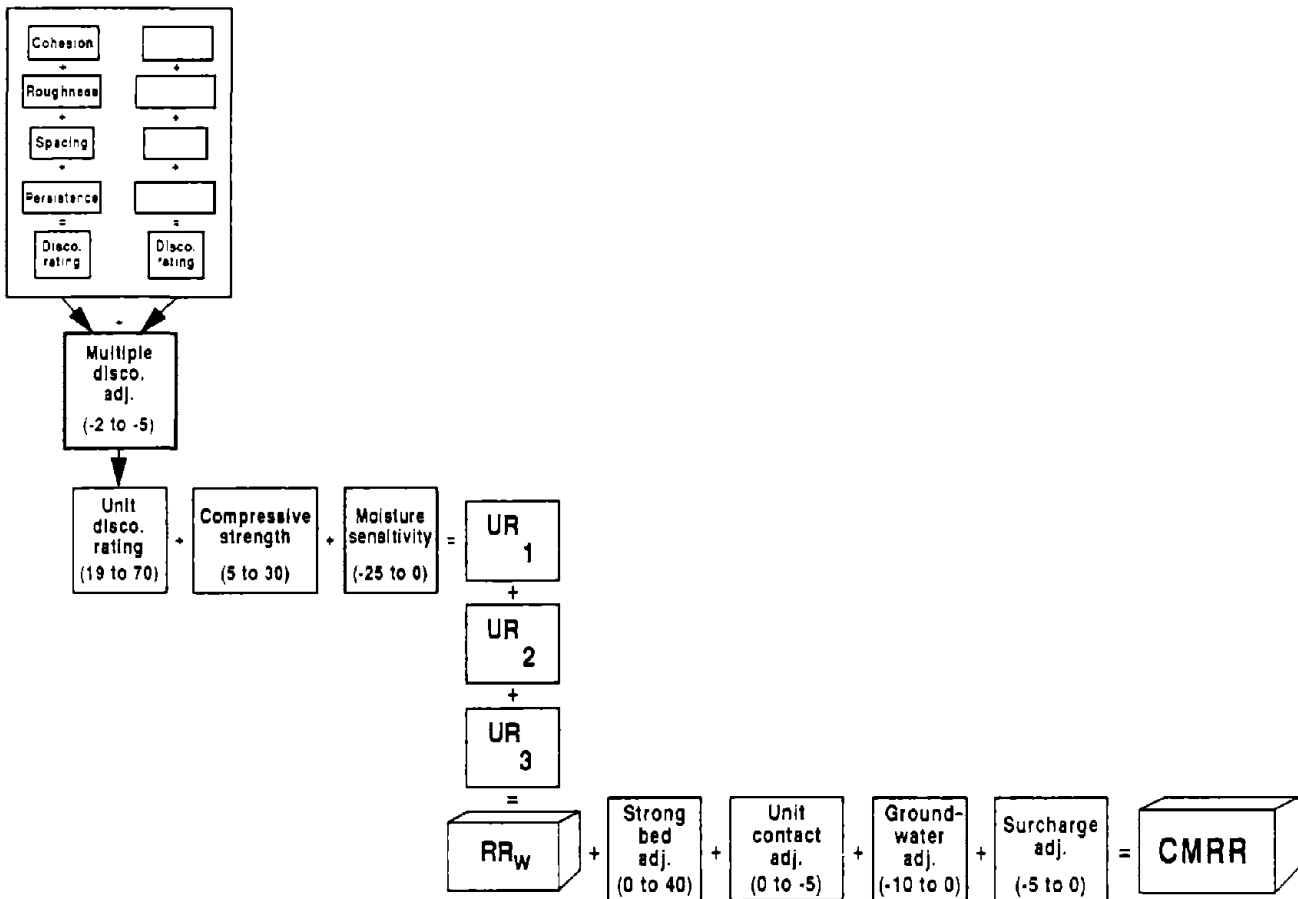


Figure 2.—CMRR calculation.

Shear Strength of Discontinuities

The ability of a discontinuity to delaminate or shear is a function of the *cohesion* and *roughness* of the discontinuity surfaces. Smooth, low-cohesion surfaces fail easily, whereas rough, high-cohesion surfaces resist shear. Shear strength of discontinuities accounts for as much as 35% of the final CMRR.

Cohesion

Cohesion is defined as the maximum strength that acts to resist sliding along a discontinuity surface when there is no normal stress. For smooth (or nearly smooth) discontinuities, it is determined largely by the strength of the bond between the two discontinuity surfaces. The cohesion of discontinuities in coal measure rocks ranges from nearly zero for slickensided surfaces to as strong as or stronger than intact rock for well-cemented surfaces.

Rocks that are finely laminated and high in clay content are particularly susceptible to delamination and slickensides. Since clay minerals are platy and deposited in quiet waters, they align parallel to form bedding in shales, resulting in very low-cohesion bedding surfaces. Often, laminations can be separated by hand in core specimens. The

laminations may not be visible to the naked eye, so for all shale or mudstones the intact rock *material* should be tested in addition to obvious bedding planes. Cohesion tests, therefore, are applied to both intact rock in a unit without discontinuities, as well as to discontinuities within a unit.

With the addition of silt and sand from a higher energy environment, bed cohesion usually increases. Larger, less platy grains form an interlocking structure, which, along with cementation, helps to resist delamination and shearing. Some features, such as fossils or mica, can *reduce* the cohesion of bedding plane surfaces.

Often, the cohesion of bedding surfaces can be estimated by the nature of the fractured wall of a roof fall. If "stairstepping" is observed, with most of the roof failure occurring along bedding, the cohesion is probably low. At the other extreme, if roof failure is observed entirely without regard for bedding, the strength of the bedding is most likely equal to or greater than that of the intact rock. In some instances, bedding may be only a color change and may not weaken the rock fabric. A rock may also have minor bedding that is strongly cemented and major bedding that is weakly cohesive (figure 3).

Other discontinuities also have cohesion properties that must be evaluated. Shears and slickensides, whether



Figure 3.—Weak bedding in a laminated shale.

parallel to or across bedding, are already planes of failure and therefore have little or no cohesion (figure 4). Slickensided surfaces receive the minimum rating. Joints are discontinuities that are also subject to evaluation for cohesion. Some joints have healed surfaces of carbonate deposition and have strong cohesion, whereas others are simple tension breaks with no cohesion.

In the CMRR, cohesion along bedding is evaluated by a splitting test with a 9-cm (3.5-in) mason chisel (figure 5). Weaker, less cohesive surfaces require fewer chisel blows to split.

Roughness

The roughness along a discontinuity surface constitutes the other component of the surface's shear strength. In the CMRR, roughness of a surface is estimated visually and classified as *jagged*, *wavy*, or *planar* (5) (figure 6). This measure is to be applied on a scale ranging from hand-sample size to several meters across a fall exposure.

The CMRR assumes that roughness significantly affects shear strength only when cohesion is in the middle range. When cohesion is high, the shear strength of the discontinuity is great regardless of its roughness. At the opposite

extreme, a slickensided surface is always weak. When the cohesion is low to moderate, however, the shear strength of a planar discontinuity is significantly less than that of a rough one.

Intensity of Discontinuities

Intensity is the other factor that determines the effect of an individual discontinuity set on overall structural competence. Intensity is determined by the *spacing* between discontinuities and the *persistence*, or extent, of each individual discontinuity. The more closely spaced and persistent a set of discontinuities, the greater the weakening effect on the rock mass. Like shear strength, intensity accounts for as much as 35% of the final CMRR.

Spacing

Spacing is the average distance between discontinuities within a unit (5). It is normally determined by counting the number of discontinuities observed along a measured length of exposed mine roof. Spacing is grouped into five classes, from very close (<6 cm (<2.5 in)) to very wide (>1.8 m (>6 ft)) (5).



Figure 4.—Slickensided surfaces in shale are extremely weak discontinuities in mine roof. (Photo: David K. Ingram, Pittsburgh Research Center, U.S. Bureau of Mines)

Persistence

Persistence is the areal extent or size of a discontinuity plane. If a feature (joint, shear, etc.) is very persistent, its ability to weaken the mine roof is greater, which is reflected as a deduction in the rating. Both vertical and horizontal persistence are recorded. For example, a joint may terminate vertically after only a few centimeters. Such a feature weakens the roof sequence much less than a major joint extending several meters upward. Similarly, broad sloping shears may cut across roof strata along the boundaries of paleochannels with much greater effect than the short, randomly oriented slickensides that are common



Figure 5.—Splitting test with a 9-cm (3.5-in) mason chisel for evaluating cohesion along bedding.

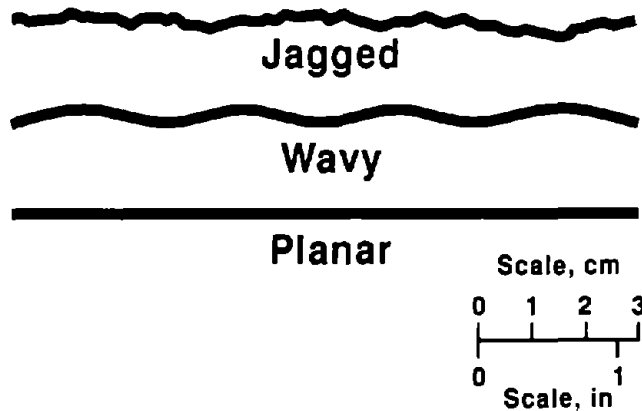


Figure 6.—Guide for visually classifying the roughness of discontinuity surfaces.

in drawrock. A very persistent shear, i.e., one that extends more than 3 m (10 ft) laterally and vertically, can form the boundary of a mine roof fall.

Number of Discontinuity Sets

Many coal measure roof rock types contain more than one discontinuity set. Some form of internal bedding is usually present, and there are often slickensides, small joints or fractures, coal spars, or other discontinuities as well. While the most significant discontinuity set is the one that most weakens the integrity of the rock, the others may have some additional effect. In these instances, the CMRR employs a *multiple discontinuity adjustment* that reduces the unit rating by as much as 5 points.

Compressive Strength

The uniaxial compressive strength of the rock material affects mine roof strength in several ways. First, it determines the ease with which new fracturing (as opposed to movement along preexisting discontinuities) will occur. Second, the compressive strength of the rock is a factor in the shear strength of discontinuities (5). The value of a rock as a strong roof bolt anchorage also depends in part on its compressive strength. A possible 30 points of the CMRR are attached to compressive strength rating.

Several index tests have been proposed to estimate compressive strength. The CMRR employs an indentation test proposed by Williamson (42). The exposed rock face is struck with the round end of a ball peen hammer, and the resulting characteristic impact reaction is compared to the chart shown in figure 7 (this chart is also reproduced on the CMRR field data sheet, explained later). It is the *nature* of the indentation, not its magnitude, that is important.

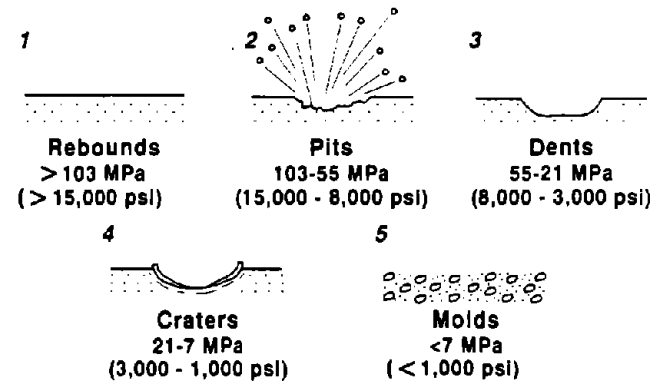


Figure 7.—Ball peen hammer impact test indicates compressive strength.

Moisture Sensitivity

Moisture sensitivity affects a rock in two ways. First, a moisture reactive rock exposed to mine air humidity can slake and slough. Second, weathering of confined rock faces, as in joint face weathering, can lead to clay expansion and hydraulic fracturing or weakening of the sequence. When sag occurs in a mine roof, delamination of the shales can open up much more surface area for water seepage, which accelerates the disintegration of moisture sensitive rocks that would otherwise have been confined.

Some mudrocks are so reactive to moisture that they disintegrate shortly after exposure to mine air. Decomposition can range from slight staining to full secondary mineralization and disintegration. Staining is often an iron rust stain due to oxidation of iron in clay minerals. This parameter is estimated visually in the field. A dripping or flow of groundwater along bedding planes or roof fractures can often cause weathering of mudrocks or shale streaks within sandstone units. Care must be taken not to mistake iron staining from the water itself for actual weathering of clay minerals (figure 8). The CMRR uses an immersion test as well as a visual estimation of moisture sensitivity (37). The degree to which a sample degrades in 24 h when immersed in water is a measure of its moisture sensitivity. Figure 9 shows the data sheet used for the immersion test.



Figure 8.—Iron-stained water leaking from mine roof.

The practice of leaving coal or rock below a reactive layer is a common and effective way to prevent exposure. In calculating the CMRR, a moisture sensitivity deduction is included only if—

- The reactive unit is exposed to humid mine air, or
- Significant inflows of groundwater are present.

The deduction can be as high as 25 points for rocks that rapidly disintegrate in contact with water.

ROOF RATINGS

After the individual unit ratings have been determined, they are combined into a single rating for the entire mine roof. Several factors are considered.

Strong Bed in the Bolted Interval

One of the most important concepts incorporated into the CMRR is that of the strong bed. Many years of experience with roof bolting throughout U.S. coalfields have found that the overall structural competence of bolted roof is very often determined by the quality of the most competent bed within the bolted interval. This fact was early recognized with mechanical bolts. Regulations of the U.S. Mine Safety and Health Administration at 30 CFR 75.204(f)(1) require that "roof bolts that provide support by suspending the roof from overlying stronger strata shall be long enough to anchor at least 12 inches into the stronger strata." Falls also occur when fully grouted resin bolts miss their anchorage in stronger strata. Many rules of thumb have been developed locally that reflect this knowledge. For example, in the Herrin (No. 6) Coal Seam in Illinois, mine roof falls are extremely rare when the Brereton limestone is at least 0.6 m (2 ft) thick in the bolted interval (8, 21).

The strong bed adjustment in the CMRR depends on several factors. The first is the contrast between the competence of the strong bed and the other roof units (figure 10). The contribution of the strong bed is most marked when it is significantly more competent than the other roof members. The second factor is the thickness of the strong bed. To be able to provide any additional support, the bed must be 30 cm (1 ft) thick, and the amount of the adjustment is maximum when the bed is at least 1.2 m (4 ft) thick. The roof bolts must also obtain at least 30 cm (1 ft) of anchorage for the adjustment to be considered. Finally, the adjustment is reduced for the thickness of the weak units that are suspended.

IMMERSION TEST

Mine _____ Date _____

Unit No. _____ Tester _____

Sample Description (lithology, bedding, etc.)

Immersion		Breakability	
<u>Observation</u>	<u>Rating</u>	<u>Observation</u>	<u>Rating</u>
<i>Appearance of Water</i>			
Clear = 0	_____	No Change = 0	
Misty = -2	_____	Small Change = -3	
Cloudy = -5	_____	Large Change = -10	
<i>Talus Formation</i>			
None = 0	_____		Total _____
Minor = -2	_____		
Major = -5	_____		
<i>Cracking of Sample</i>			
None = 0	_____		
Minor-Random = -2	_____		
Major-Preferred Orientation = -5	_____		
Specimen Breakdown = -15	_____		
Total	_____		

IMMERSION TEST

Procedure for Immersion Test

1. Select sample(s) \approx hand-sized.
2. Test for hand breakability.
3. Rinse specimen (to remove surface dirt, dust, etc.).
4. Immerse in water for 24 h.
5. Observe and rate water appearance, talus formation, and cracking of sample.

Sum Rating for Immersion Test Index.

6. Retest for hand breakability.

Determine Breakability Index.

7. Use the larger negative value of the Immersion Test Index or the Breakability Index as the Weatherability Rating.

Figure 9.—Immersion test data sheet.

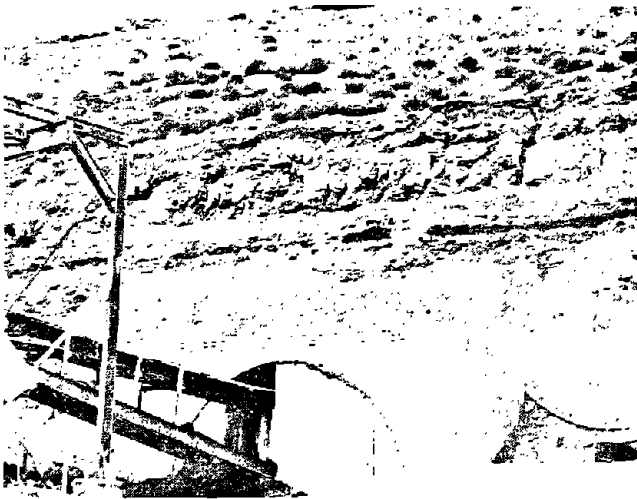


Figure 10.—Structural unit that qualifies as a strong bed.

Number of Units

Many workers have indicated that mine roof containing numerous lithologic contacts is less competent than roof consisting of a single rock type (28). When depositional processes change and deposit distinctly different material, there is generally (but not always) a sharp contact between units. Usually this means a relatively weak contact, as indicated by the fact that bed contacts are often not preserved intact in core or fallen roof rock. In other instances, the contact may be gradational and may not represent a weak plane. The characteristics of a contact

surface (cohesion and roughness) should be noted, and only the weak contacts are considered in determining the deduction. The maximum deduction from the CMRR is 5 points when more than four weak contacts are present.

Groundwater

Groundwater leakage is most prevalent in shallow mines, particularly beneath stream valleys. Groundwater can be introduced in several other ways, including leakage from pooled water in abandoned mines and fracturing of overlying aquifers from high-extraction mining. Groundwater can activate water-sensitive rocks or hydraulically wedge already fractured rocks. A deduction from the CMRR is made for excessive groundwater inflow leaking into the roof sequence at *any* point, not at each unit. The maximum deduction for flowing groundwater is 10 points.

Overlying Beds

The strength of rocks overlying the bolted interval will affect the stability of the bolted interval. If the rocks above the bolted interval are significantly weaker, they may apply an additional load to the roof beam. This was exemplified in a western U.S. mine where 1.2 m (4 ft) of relatively strong top coal was overlain by 6 m (20 ft) of weak, rooted claystone. Because the coal needed to carry some of the extra weight of the incompetent claystone, stability was reduced. The CMRR accounts for the surcharge with up to a 5-point deduction.

THE CMRR PROCEDURE

The following discussion outlines how the CMRR system is used and the general procedures to follow to compute the CMRR. Step-by-step procedures for the calculation are presented in appendix B.

DATA COLLECTION

Data from any and all available mine roof exposures should be collected for CMRR evaluation. Underground exposures are primarily roof falls and overcasts. Core logs and borescope test holes may also be used. Procedures for determining the CMRR using only drill core are currently being developed by USBM ground control researchers.

All of the data from beds exposed in any roof fall or other exposure are gathered and tabulated on the CMRR field data sheet (figure 11). While it is sound geotechnical practice to document the entire exposure, normally only

the rocks within and just above the bolted interval are included in the CMRR calculation.

Several local geologic structures, such as paleochannel margins, clay veins, and faults, may cause mine roof to fail. Although these features may have an important effect on roof control, they are, on the whole, localized in occurrence. The CMRR does not attempt to average in the effects of these local structures. Rather, they should be treated as anomalies, partitioned off and evaluated separately.

The first step in calculating the CMRR is to visually break the strata into individual units. Units are defined as rock intervals with distinct, structural characteristics (figure 12). Units must also be at least 15 cm (6 in) thick. A coal measure roof sequence often contains numerous lithologic changes, but in many instances it is unnecessary to describe and evaluate each thin, individual rock layer. One example would be a sequence of "stackrock," a thinly

COAL MINE ROOF RATING (CMRR) FIELD DATA SHEET DIRECTIONS

Unit - Any distinct rock bed > 15 cm (>6 in) thick that forms a structural member in the roof.

Discontinuity - Any surface that 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 hand sample as indicated by a hammer impact test.

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

Spacing - Indicate how closely spaced the discontinuities are.

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 9-cm (3.5-in) 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.

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. Next, describe each discontinuity (bedding plane, slickenside, inclusion, crossbed, etc.) within the bed by the criteria provided below each column.
5. Three rows are provided for up to three discontinuities.

Figure 11.—CMRR field data sheet—Continued.

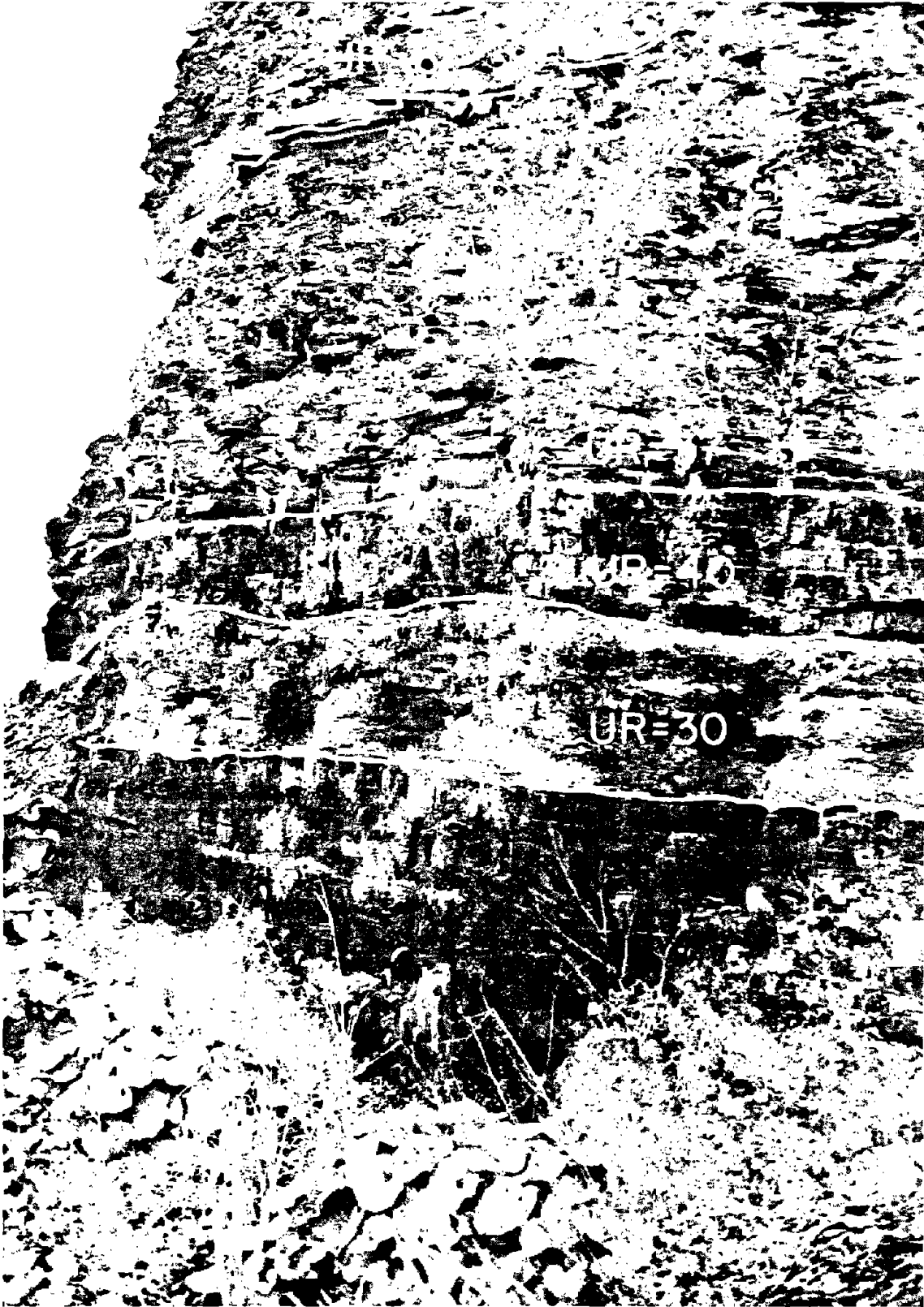


Figure 12.—CMRR units are defined in the bolted interval. UR - unit rating.

bedded sequence of micaceous sandstone and shale that resembles the side view of a thick shopping catalog (hence the expression "catalog rock"). The correct way to apply the CMRR is to group this rock into a single structural unit and avoid splitting it into numerous beds.

Data collection begins with the unit forming the immediate mine roof and works upward through the exposure. It includes visual observations, measurements, chisel tests, and hammer indentation tests. The CMRR field data sheet guides the data collection process.

CMRR CALCULATION AND OUTPUT

After all of the data have been gathered, the CMRR can be calculated. First, unit ratings are determined for each unit. The procedure is guided by the unit rating calculation sheet (figure 13). It begins by determining ratings for each discontinuity set within the unit. Ratings for shear strength (cohesion and roughness) and intensity (spacing and persistence) are obtained from tables 1 and 2, respectively. These ratings are summed to obtain individual discontinuity ratings. The most significant discontinuity is the one with the lowest individual discontinuity rating. If more than one discontinuity set is present, a multiple discontinuity adjustment may be applied using table 3. The remaining two unit parameters, strength and moisture sensitivity, are obtained from tables 4 and 5, respectively. All of the individual ratings are then summed to obtain the unit rating. The process is repeated for each of the units in the sequence.

Table 1.—Cohesion-roughness rating

Roughness	(1)	(2)	(3)	(4)
	Strong cohesion	Moderate cohesion	Weak cohesion	Slickensided
(1) Jagged . . .	35	29	24	10
(2) Wavy . . .	35	27	20	10
(3) Planar . . .	35	25	16	10

NOTE.—If unit has no bedding or discontinuities, then apply test to the intact rock. Strong cohesion implies that the discontinuities have no weakening effect on the rock.

Table 2.—Spacing-persistence rating

Persistence, m (ft)	(1)	(2)	(3)	(4)	(5)
	> 1.8 m (> 6 ft)	0.6 to 1.8 m (2 to 6 ft)	20 to 61 cm (8 to 24 in)	6 to 20 cm (2.5 to 8 in)	< 6 cm (< 2.5 in)
(1) 0 to 0.9 (0 to 3)	35	30	24	17	9
(2) 0.9 to 3 (3 to 10)	32	27	21	15	9
(3) 3 to 9 (10 to 30)	30	25	20	13	9
(4) > 9 (> 30)	30	25	20	13	9

NOTE.—If unit has no bedding or discontinuities, then enter 35. If cohesion is strong, then enter 35.

Table 3.—Multiple discontinuity set adjustment

Two lowest individual discontinuity ratings both lower than—	Adjustment
30	-5
40	-4
50	-2

Table 4.—Strength rating

Strength, MPa (psi)	Rating
(1) > 103 (> 15,000)	30
(2) 55 to 103 (8,000 to 15,000)	22
(3) 21 to 55 (3,000 to 8,000)	15
(4) 7 to 21 (1,000 to 3,000)	10
(5) < 7 (< 1,000)	5

Table 5.—Moisture sensitivity rating

Moisture sensitivity	Rating
(1) Not sensitive	0
(2) Slightly sensitive	-3
(3) Moderately sensitive	-10
(4) Severely sensitive	-25

NOTE.—Use immersion test for better accuracy. Apply adjustment only if the unit is exposed as the immediate roof or flowing groundwater is present and if the anticipated service life of entry is long enough to allow decomposition to occur.

Next, the unit ratings are combined to obtain the CMRR using the roof rating calculation sheet (figure 14). The thickness-weighted average (RR_w) of the unit ratings within the bolted interval is determined first. Adjustments for the strong bed, unit contacts, groundwater, and surcharge are then made using tables 6-9, respectively. The final result is the CMRR, scaled from 0 to 100, which represents the structural competence of the bolted interval (figure 15).

FIELD EXAMPLE USING THE CMRR

The following example, taken from a mine working the Clarion No. 4 Seam in southeastern Ohio, illustrates the CMRR data collection and calculation procedures. The immediate mine roof in this exposure consisted of 91 cm (36 in) of highly laminated black shale, with coal streaks and high-angle slips. The shale was overlain by 91 cm (36 in) of massive limestone, unbedded, with rare brown nodules. Fully grouted bolts, 1.2 m (4 ft) long, are used for primary roof support.

UNIT RATING (UR) CALCULATION SHEET

Mine Name _____ Date _____

Location _____ Data Collected by _____

1) Calculate the Individual Discontinuity Rating Unit No. _____

	<u>Discontinuity</u>		
	<i>Set 1</i>	<i>Set 2</i>	<i>Set 3</i>
Cohesion-Roughness (table 1)	<input style="width: 40px; height: 25px;" type="text"/>	<input style="width: 40px; height: 25px;" type="text"/>	<input style="width: 40px; height: 25px;" type="text"/>
	+	+	+
Spacing-Persistence (table 2)	<input style="width: 40px; height: 25px;" type="text"/>	<input style="width: 40px; height: 25px;" type="text"/>	<input style="width: 40px; height: 25px;" type="text"/>
Individual Discontinuity Ratings	<input style="width: 40px; height: 25px;" type="text"/>	<input style="width: 40px; height: 25px;" type="text"/>	<input style="width: 40px; height: 25px;" type="text"/>

- | | | |
|---|---|---|
| 2) Enter the lowest of the Individual Discontinuity Ratings | <input style="width: 40px; height: 25px;" type="text"/> | |
| | + | |
| 3) If there is more than one Discontinuity set, enter the Multiple Discontinuity Adjustment from table 3. Otherwise, enter 0. | <input style="width: 40px; height: 25px;" type="text"/> | |
| | + | |
| 4) Calculate the Unit Strength (table 4) | <input style="width: 40px; height: 25px;" type="text"/> | |
| | + | |
| 5) Calculate the Unit Moisture Sensitivity (table 5) (this applies only to Unit 1, or if upper Unit is exposed to water) | <input style="width: 40px; height: 25px;" type="text"/> | |
| | = | <input style="width: 40px; height: 25px;" type="text"/> |
| | | = Unit Rating (UR) |

Figure 13.—Unit rating calculation sheet.

ROOF RATING (CMRR) CALCULATION SHEET

Mine Name _____ Date _____
 Location _____ Data Collected by _____

1) Calculate the weighted average of the Unit Ratings (RR_w)

	UR		Unit Thickness (m (in))				
1.		×		=			
			+				
2.		×		=			
			+				
3.		×		=			
			+				
4.		×		=			
			+				
	<i>Bolted Interval (BI)</i> (m (in))						
						=	
					(BI)		(RR_w)
							(RR_w)

2) Calculate Strong Bed Difference (SBD)

Largest (UR) = Strong Bed (SB)

(SB) - RR_w = (SBD)

3) Calculate the Strong Bed Adjustment
(table 6)

4) Calculate the Unit Contact Adjustment
(table 7)

5) Calculate the Groundwater Adjustment
(table 8)

6) Calculate the Surcharge Adjustment
(table 9)

+	
+	
+	
+	
=	
	= CMRR

Figure 14.—Roof rating calculation sheet.

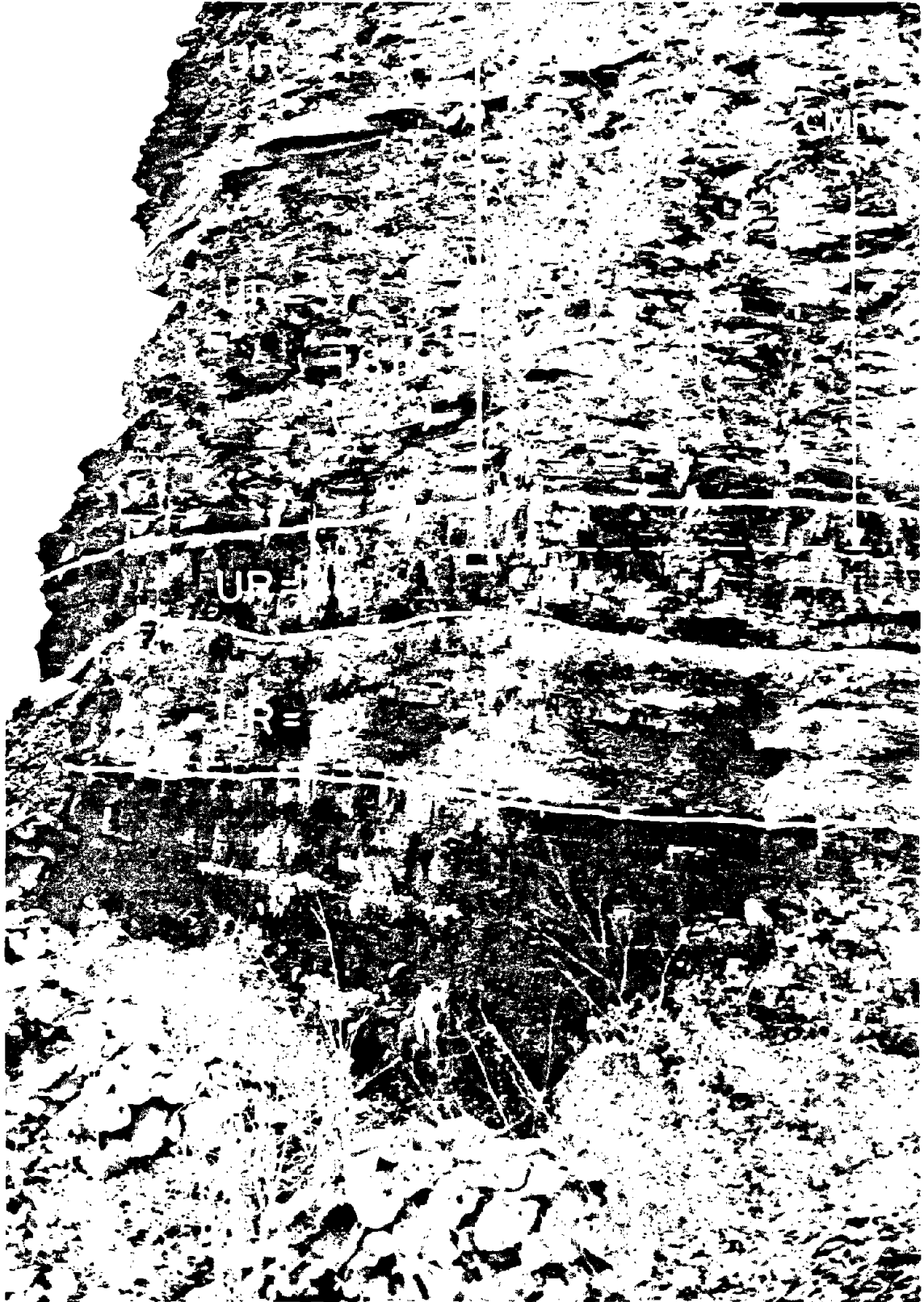


Figure 15.—CMRR calculated for a roof sequence with a 1.8-m (72-in) bolt. UR = unit rating.

Table 6.—Strong bed adjustment

Thickness of strong bed, m (ft)	Strong bed difference							
	5-9	10-14	15-19	20-24	25-29	30-34	35-40	>40
0.3 to 0.6 (1 to 2)	0	2	4	5	7	8	9	10
0.6 to 0.9 (2 to 3)	2	4	7	9	12	14	17	20
0.9 to 1.2 (3 to 4)	3	5	10	14	18	21	25	30
>1.2 (>4)	4	8	13	18	23	28	34	40

NOTE.—The strong bed adjustments should be reduced to account for the weight of the weaker rock suspended from it as follows:

Thickness of weaker rock, m (ft)	Multiply strong bed adjustment by—
0-0.9 (0-3)	1.0
0.9-1.8 (3-6)	0.7
>1.8 (>6)	0.3

Table 7.—Unit contacts adjustment

Number of major contacts	Adjustment
0	0
1 to 2	-2
3 to 4	-4
>4	-5

NOTE.—Apply only if unit contacts are significant planes of weakness (persistent, low cohesion).

Table 8.—Groundwater adjustment

Condition	Adjustment
Dry	0
Damp	-2
Light drip	-4
Heavy drip	-7
Flowing	-10

NOTE.—Applies only to groundwater present in roof (not floor or ribs).

Table 9.—Surcharge adjustment

Condition	Adjustment
Upper units approximately equal in strength to bolted interval	0
Upper units significantly weaker than bolted interval	-2 to -5

Figure 16 shows the completed CMRR field data sheet. The evaluation begins with the shale (unit 1), which forms the immediate roof. Using the ball peen hammer impact test, the strength of the shale is determined to be in the 7-21 MPa (1,000-3,000 psi) range. The shale also occasionally slakes when exposed to moisture and is rated moderately sensitive. Two sets of discontinuities that

weaken the rock are identified in the shale. In the first discontinuity, bedding has weak cohesion (as determined by one to three blows with the mason chisel). The bedding surface is planar. The laminated bedding is closely spaced (<6 cm (<2.5 in)), flat, and persistent from 0.9-3 m (3-10 ft). The slips, which are the second discontinuity, are moderately spaced (0.6-1.8 m (2-6 ft)) apart, persistent (3-9 m (10-30 ft)), and are wavy and slickensided.

The limestone above (unit 2) is extremely strong (compressive strength >103 MPa (>15,000 psi) and does not react to moisture. The nodules, the only discontinuity, are cohesive with the limestone and moderately spaced. They are interlocked in the bedding (jagged roughness) and persistent from 3-9 m (10-30 ft).

Next, the unit rating for each unit is calculated (see completed unit rating calculation sheets at figures 17-18). The conversion tables (tables 1-5) are used to convert the raw data for the unit rating calculation sheet. To calculate the individual discontinuity rating for the bedding (set 1) of unit 1, refer to table 1 for cohesion-roughness. The corresponding value is 16. Repeat the procedure for the conversion of the spacing-persistence of the bedding.

The bedding is the weakest discontinuity in the shale, with a rating of 25. The slip planes have an individual discontinuity rating of 35. A multiple discontinuity adjustment of -4 results from the slips. The unit rating of the shale is 31 without considering the effects of water on the shale, and 21 when the moisture sensitivity adjustment is included (figure 17). In this case, since the exposure is damp, 10 points are deducted for moisture sensitivity. The unit rating of the limestone (unit 2) is 83 (figure 18).

The roof rating calculation sheet (figure 19) is used to determine the final CMRR. Because the roof bolts are 1.2 m (4 ft) long, only the bottom 30 cm (1 ft) of the limestone is included in the calculation of the RR_u of the unit ratings. In this case, the $RR_u = 36$. The bolts obtain 30 cm (1 ft) of anchorage in the limestone, however, so

UNIT RATING (UR) CALCULATION SHEET

Mine Name MINE #2 Date 7-30-92

Location 4 NORTHWEST MAINS Data Collected by E. MOLINDA

1) Calculate the Individual Discontinuity Rating

Unit No. 1 SHBLE

	<u>Discontinuity</u>		
	<u>Set 1</u>	<u>Set 2</u>	<u>Set 3</u>
Cohesion-Roughness (table 1)	16	10	
	+	+	+
Spacing-Persistence (table 2)	9	25	
Individual Discontinuity Ratings	25	35	

- | | | |
|---|-----|--------------------|
| 2) Enter the lowest of the Individual Discontinuity Ratings | 25 | |
| | + | |
| 3) If there is more than one Discontinuity set, enter the Multiple Discontinuity Adjustment from table 3. Otherwise, enter 0. | -4 | |
| | + | |
| 4) Calculate the Unit Strength (table 4) | 10 | |
| | + | |
| 5) Calculate the Unit Moisture Sensitivity (table 5) (this applies only to Unit 1, or if upper Unit is exposed to water) | -10 | |
| | + | |
| | 21 | = Unit Rating (UR) |

Figure 17.—Completed unit rating calculation sheet for unit 1.

UNIT RATING (UR) CALCULATION SHEET

Mine Name MINE #2 Date 7-30-92
 Location 4 NORTHWEST MAINS Data Collected by G. MOLINDA

1) Calculate the Individual Discontinuity Rating

Unit No. 2 LIMESTONE

	<u>Discontinuity</u>		
	Set 1	Set 2	Set 3
Cohesion-Roughness (table 1)	28		
	+	+	+
Spacing-Persistence (table 2)	25		
Individual Discontinuity Ratings	53		

2) Enter the lowest of the Individual Discontinuity Ratings

53
+

3) If there is more than one Discontinuity set, enter the Multiple Discontinuity Adjustment from table 3. Otherwise, enter 0.

0
+

4) Calculate the Unit Strength (table 4)

30
+

5) Calculate the Unit Moisture Sensirivity (table 5) (this applies only to Unit 1, or if upper Unit is exposed to water)

0

83

= Unit Rating (UR)

Figure 18.—Completed unit rating calculation sheet for unit 2.

ROOF RATING (CMRR) CALCULATION SHEET

Mine Name MINE #2 Date 7-30-92
 Location 4 NORTHWEST MAINS Data Collected by G. MOLINDA

1) Calculate the weighted average of the Unit Ratings (RR_w)

	UR		Unit Thickness (m (in))			
1.	21	x	.36	=	756	
2.	83	x	12	=	996	
3.		x		=		
4.		x		=		
			48		1,752	
	Bolted Interval (BI) (m (in))				48	= 36 (RR _w)
			36			(RR _w)

2) Calculate Strong Bed Difference (SBD)

Largest (UR) = 83 Strong Bed (SB)

83 (SB) - .36 RR_w = 47 (SBD)

3) Calculate the Strong Bed Adjustment
(table 6)

4) Calculate the Unit Contact Adjustment
(table 7)

5) Calculate the Groundwater Adjustment
(table 8)

6) Calculate the Surcharge Adjustment
(table 9)

+
21
+
-2
+
-2
+
0
=
53

53 = CMRR

Figure 19.—Completed roof rating calculation sheet.

the entire thickness of the limestone is included in the determination of the strong bed adjustment (table 6). First, the strong bed difference (SBD) is found to be 47 by subtracting the RR_w from the unit rating of the limestone. Using table 6, the strong bed adjustment is found to be 30. This adjustment is reduced to account for the dead weight of the shale using the formula noted beneath table 6. The

final strong bed adjustment is 21 points. Other adjustments are then made: -2 points for the contact between the shale and limestone (table 7), and -2 points for damp groundwater conditions (table 8). In this example, there is no surcharge adjustment (table 9). The final CMRR is 53.

APPLICATIONS

Currently, the CMRR has been determined for 97 roof exposures from 75 coal mines across the United States. These mines range in size from a small, new mine in southern West Virginia to some of the largest longwall operations in the Nation. All of the major U.S. coal basins are represented, and the distribution by region approximately reflects the extent of mining activity in that region. The data can be partitioned to reflect the following three broad classes of roof based on a scale of 0 to 100: *weak* (0-45), *moderate* (45-65), and *strong* (65-100) (figure 20). The database was further partitioned by both region and CMRR. Ninety-five percent of the data from the northern Appalachian region falls within the *moderate* to *weak* categories. Roof rocks from this region generally are weaker because of the higher percentage of claystones

and mudrocks. Seventy-six percent of CMRR values from the southern Appalachian region fall within the *moderate* to *strong* categories. The southern Appalachian region is generally characterized by more sand in the roof sequence, resulting in stronger roof rocks. Most of the CMRR values from Utah mines fall within the *strong* range. This supports past observations that roof rocks in the Western United States are generally stronger than rocks composing the eastern U.S. roof sequences. These observations remain preliminary and must await a larger database for confirmation.

The development of the Analysis of Longwall Pillar Stability (ALPS) program has constituted a significant advance in the design of chain pillars for longwall gate roads (23). This program provides a safety factor for

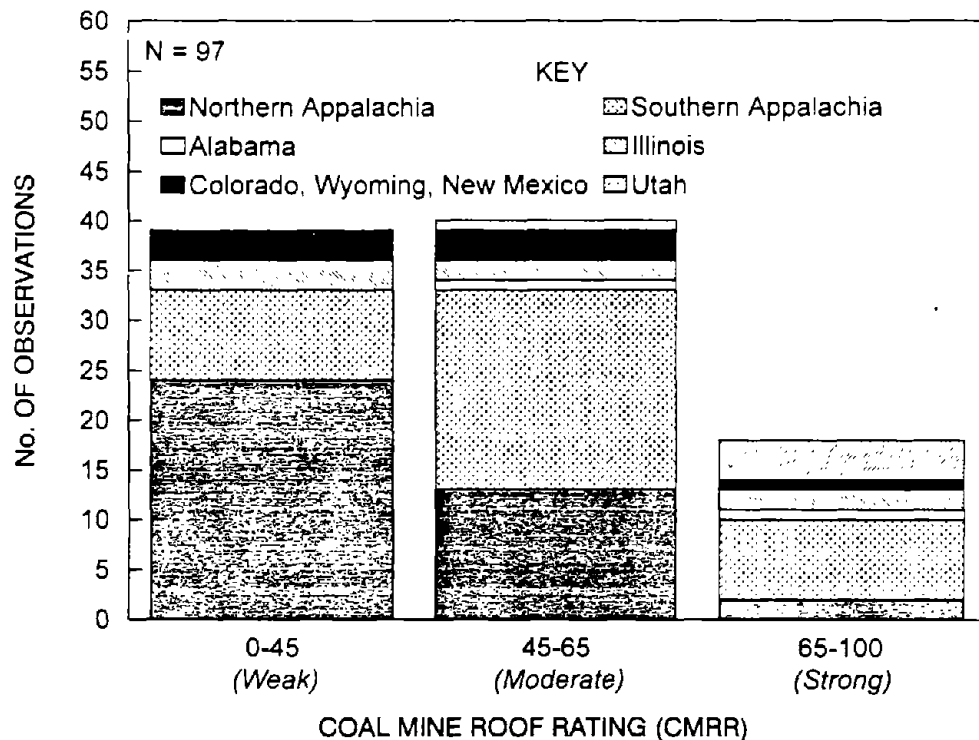


Figure 20.—Distribution of CMRR values by region.

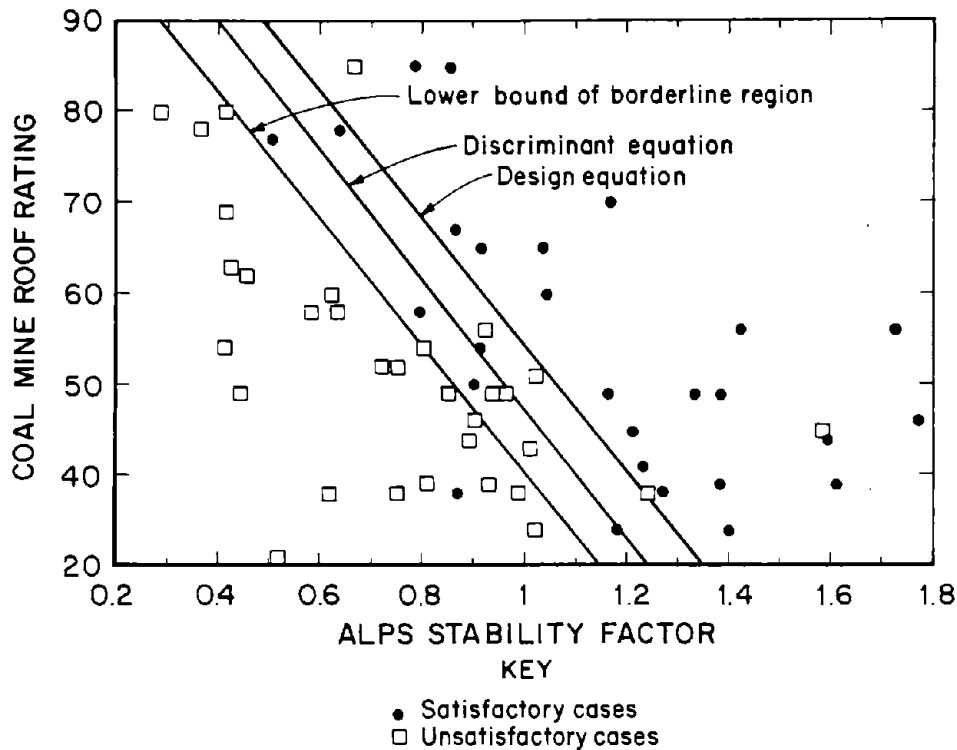


Figure 21.—Relationship between the success or failure of gate road designs and CMRR/ALPS.

given coal pillar sizes based on the applied loads and strength of the proposed pillar. By integrating the CMRR into the ALPS program, the accuracy of the program in evaluating the success or failure of different gate road designs has been significantly improved (24). By using only the ALPS safety factor and the CMRR, the likelihood of success or failure of a gate road design can be reliably predicted (figure 21).

Numerous applications are anticipated for the CMRR. Research is currently underway to develop a database of

influence factors related to mine roof falls (intersection spans, valley effects, roof bolt type, depth of cover, etc.). These variables will be analyzed statistically to determine a formula for the probability of failure of a given roof type. These probabilities can then be calculated into a hazard map. The CMRR will be the variable used to represent the roof geology as one of the influence factors. Other applications include using the CMRR as a criterion for roof bolt selection and extended/wide cuts.

CONCLUSIONS

The CMRR developed by the USBM responds to a longstanding need in the coal mining industry to translate qualitative geologic description of roof rocks into quantitative engineering data for analysis. The system provides direction for the collection of geotechnical data and a methodology for converting those data into a CMRR. The system is designed to eliminate wordy geologic description of roof sequences. It provides to technical mine personnel, even those without extensive geologic training, a simple methodology for rating the inherent structural competence of coal mine roof rocks. Armed with this information, the

engineer can begin to predict roof stability, then design support to ensure it.

The underlying concept of the system is that discontinuities in bedded coal measure rocks largely determine their structural integrity. Other important geotechnical parameters are the unconfined compressive strength of the intact rock and its moisture sensitivity. These parameters form the base roof rating of the roof sequence, which is then modified to account for the presence of a strong bed, surcharge, unit contacts, and groundwater inflow. Procedures have been developed for field data collection and

calculation of CMRR values. All of these procedures are facilitated with field data sheets, conversion tables, and calculation sheets. With practice, the entire evaluation of a roof exposure, from data collection to final roof rating calculation, can be accomplished in 30 min.

Field testing of the CMRR confirms that the roof rating values that are generated accurately represent the structural competence of roof sequences. The CMRR has already made an important contribution to longwall gate

entry design. In the future, the CMRR promises to provide the missing link between geology and roof support selection and design. Other research is studying the application of the CMRR to hazard analysis, extended-cut evaluation, and roof cavability for coal pillar extraction. The integration of the CMRR into many facets of ground control design will significantly contribute to a safer work environment for the Nation's underground mineworkers.

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APPENDIX A.—SUMMARY OF ROOF CLASSIFICATION SYSTEMS

Table A-1 summarizes diverse roof classification systems that were developed for coal mining prior to the CMRR, giving brief descriptions of the approach taken. These systems consider both engineering and geologic

variables to arrive at final classifications for different purposes. It is from this body of important work that the CMRR was developed.

Table A-1.—Summary of roof classification systems

Author and reference No.	Year	Approach	Description
Buddery and Oldroyd (6)	1992	Geotechnical	Roof classified by testing strength of bedding planes with impact splitter.
Caudle (7)	1974	Geotechnical	Roof falls are classified by their mechanism of failure, and support is recommended.
Damberger and others (8)	1980	Geologic	Identified two major roof types over Herrin (No. 6) Coalbed in Illinois and evaluated roof quality of each.
Ferm and others (12)	1978	Geologic/statistical	Statistically correlated between Virginia roof lithologies and roof conditions.
Hsuing and others (13)	1988	Geotechnical	Classifies main and immediate roofs for use in selection of powered supports for longwall faces.
Hylbert (14)	1978	Geologic	Kentucky coal mine roof is classified into four lithologic types and relates to falls.
Karmis and Kane (19)	1984	Geotechnical	A roof classification is developed for use in a statistical study of roof failures in Virginia mines.
Kester and Chugh (21)	1980	Geologic	Evaluates a number of geologic properties from Illinois cores and devises a ratings system.
Milici and others (26)	1982	Geologic	Devised a roof instability index (RII) (favorable types/ nonfavorable types) from extensive mapping of Virginia coalfields.
Moebs and Stateham (28)	1985	Geologic	Roof falls are classified by cause into seven groups—four related to geology and three to stress.
Newman and Bieniawski (31)	1986	Geotechnical	Modifies Bieniawski's Rock Mass Rating (RMR) by adding multipliers for stress, weatherability, and roof reinforcement.
Patrick and Augherbaugh (33)	1979	Roof fall	Roof falls are classified strictly by their geometry.
Schaffer (35)	1985	Geologic	Local classification for Illinois based on clay dike size, orientation, and roof type.
Shepherd and Burston (36)	1977	Roof fall	Proposed a roof fall classification based on height and shape, as well as a six-level roof condition index.
Sinha and others (38)	1986	Geotechnical	Classification based on Bieniawski's Rock Mass Rating (RMR) and modified mining methods, and reflects problems of mines in India.
Stingelin and others (39)	1979	Geologic	Roof fall data and drill cores were used to produce roof hazard maps in the northern Appalachian Basin.
Weir (41)	1969	Geologic/roof fall	Classified roof falls with a combination of shape and lithologic descriptors.
Zhou and others (43)	1988	Geotechnical	Developed a roof rating to predict roof damage in multiple-seam mining using geologic and spatial parameters.

APPENDIX B.—CMRR STEP-BY-STEP PROCEDURE

The following discussion is a step-by-step procedure on how to—

- Collect the field data and
- Calculate the CMRR.

Data sources for the CMRR may include overcasts, core, highwall, and borescopes, but the roof fall is the best source of data. Equipment needed includes a ball peen hammer, a 9-cm (3.5-in) mason chisel, a tape measure, and sample bags.

FIELD DATA COLLECTION

Upon identifying the exposure to be rated, one must include all of the data available. If a 3-m (10-ft) high roof fall is to be evaluated, include all 3 m (10 ft) of rock, even though a 1.8-m (6-ft) roof bolt may be planned for the area. These data are necessary to calculate the surcharge adjustment. It will also be necessary if one wishes to recalculate the CMRR for longer or shorter bolts.

Determine the Number of Units

First, one determines how many units are to be considered in the bolted interval (figure 12). A unit is defined as a distinct structural entity. Designate as a unit that lithologic bed or sequence of beds forming a distinct strong or weak interval. In coal measure rocks, thin beds are often common, but it is preferable to group beds of like physical properties into one unit.

CMRR Field Data Sheet

The CMRR field data sheet can now be completed (figure 11). The general directions for collecting data and completing the field data sheet are given on the reverse of the sheet. There is a space for three structural units on each sheet labeled Unit No. 1, 2, and 3. If more units are identified, additional sheets should be used. Begin with the bed immediately above the coal seam as unit No. 1, then work *up* the sheet as though looking from the coalbed to the top of the roof fall. The field data sheet is divided into two large categories at the top designated "UNIT" and "UNIT DISCONTINUITIES." The worker is asked to:

1. Record the characteristics of the unit, then
2. Describe the discontinuities that disrupt the bed.

Categories are provided for most of the characteristics described on the field data sheet. For example, observations of discontinuity surface roughness are divided into

three categories: jagged, wavy, or planar. Interpolation between categories is permitted and encouraged.

Unit Properties

Starting with the first unit above the coalbed, measure (or estimate) its *thickness*. Then use common geologic symbols to draw the unit and features in the *strip log* column. Use symbols to represent features such as fossils, crossbedding, slickensides, etc., as observed. A written *description* in the next column to the right can further characterize the unit. Next, estimate the unconfined compressive *strength* of the unit by striking the exposed rock face or a sample with the round end of the ball peen hammer. The resulting characteristic impact reaction, compared with the five types of reactions illustrated on the lower left of the CMRR field data sheet, indicates the compressive strength (an enlarged view of the five reactions is shown at figure 7). The *nature* of the reaction, not its magnitude, is what is important. The hammer blow should be a medium strike—not enough to shatter the sample, but sufficient to create an indentation. Identification of the type of indentation can be aided by fingering the sample.

Next, estimate the degree of *moisture sensitivity* of the rock using the standard in the bottom part of that column on the field data sheet (the range is "not sensitive" to "severely sensitive"). Moisture sensitivity is estimated by (1) visually estimating rust staining on rocks and (2) conducting an immersion test. Figure 9 shows the data sheet used for the immersion test. This slaking test requires a hand sample of rock to be immersed in water for 24 h. The degree of disintegration of the sample is a measure of its moisture sensitivity. The immersion test data sheet guides the observation of the sample degradation. Clay absorption of water varies from immediate to none at all. If a slake test is impossible, a visual estimate of the degree of physical degradation (flaking debris) or staining can be made.

Unit Discontinuity Properties

At this point, the discontinuities within the bed are evaluated. There is space for three different discontinuities for each unit on the CMRR field data sheet, if necessary. However, only the two weakest enter into the calculation.

Discontinuities include bedding, joints, slickensides, laminations, crossbedding, lag deposits, and anything internal to the unit that serves to disrupt continuity. In coal measure rocks, bedding is nearly always present. Therefore, an evaluation of the bedding characteristics is almost always appropriate. The only discontinuities to be analyzed are those that weaken the rock. For example,

bedding may be evident by a color change, but if there is no associated fabric weakness, it should not be evaluated as a discontinuity.

The *cohesion* along the identified discontinuities is evaluated by striking a hand sample of rock parallel to bedding with a 9-cm (3.5-in) mason chisel (figure 5). The number of blows necessary to split the sample is the measure of its cohesiveness. Again, the standard is shown in the bottom of that column on the field data sheet and ranges from strong to slickensided. For cohesion to be rated as strong, the discontinuity must have no weakening effect on the rock unit. If no bedding or other discontinuities are present in the sample, the intact rock is tested for cohesion with a chisel.

The next column to the right is for recording *roughness*. Roughness refers to the texture of the discontinuity surface (figure 6). The scale of interest ranges from approximately 5-30 cm (2-12 in). If the surface is planar and subjected to shear forces, it is more likely to slip. If the surface is wavy or jagged, the surface is more likely to resist shearing. The surface of a slickenside has an extremely low coefficient of friction and has, in fact, already

failed in shear. As before, the standard is shown in the bottom of that column on the field data sheet.

The *spacing* between the discontinuities is measured and assigned a value using the ranges shown in the bottom of that column. An average spacing is used for clustered discontinuities. For example, bedding within a shale may occur every 13-25 mm (0.5-1.0 in). A value of 5 would be entered in the *spacing* column (figure 16). Spacing can apply to other discontinuities, such as joints. Often, bedding, cohesion, and spacing are indicated by the ragged edge of a mine roof fall. If bedding is closely spaced and weak, the fall edge will be closely "stairstepped."

Persistence is recorded in the next column to the right. This refers to the degree at which a discontinuity persists or extends over an area. An example would be large broad slip planes that sweep down from a bedding contact at 45° and often flatten out to bedding plane slips on the lower contact (figure B-1). The degree to which these slip planes are vertically and laterally continuous determines their impact on roof stability. The standard shown in the bottom of that column on the field data sheet groups the distances and assigns a ranking value.

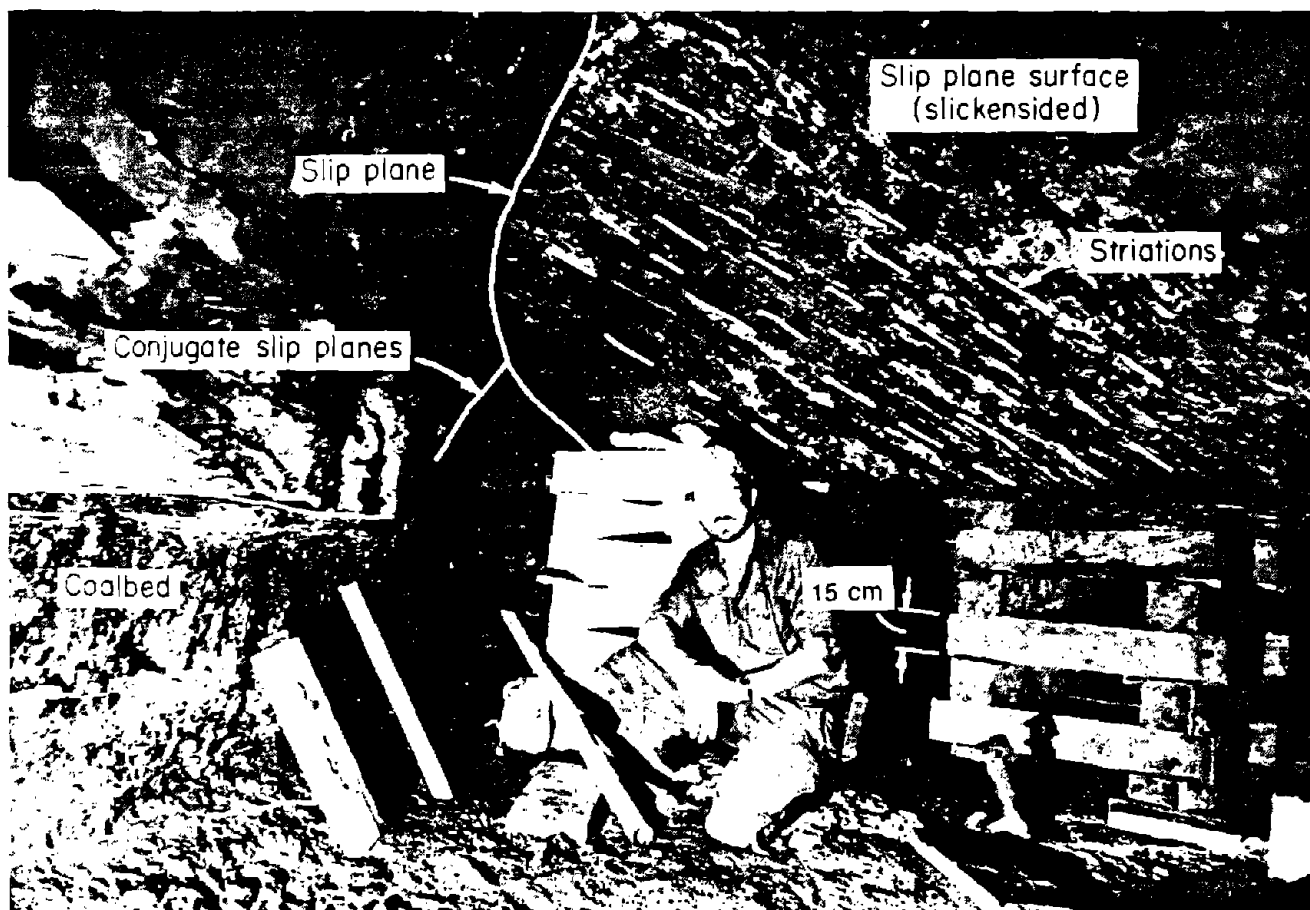


Figure B-1.—Broad slip plane of high persistence.

The remaining column to the right, discontinuity *orientation*, which includes *strike* and *dip*, refers to nonhorizontal breaks in the rock. The orientation of linear roof breaks relative to direction of drive is important to mine roof failure. Joints, slip planes, or faults that are undermined by openings parallel to their strike are the most hazardous.

On the CMRR field data sheet, each main row reflects the individual units in the sequence. Between these rows, space is provided to characterize the contacts *between* units in much the same way that the internal units were characterized. Delamination and shearing along these contacts are often observed and frequently cause roof falls. Only the cohesion and roughness of these contacts are evaluated. Since it is difficult to find a hand sample of bed contacts, it is usually necessary to estimate these parameters visually. Three types of contacts exist between beds: (1) sharp, (2) graded, and (3) alternating.

This completes the data collection process for the CMRR. The evaluation of the above parameters provides the data necessary to calculate the unit rating. This evaluation is repeated for each subsequent unit and contact in the mine roof sequence.

UNIT RATING CALCULATION

Using the raw field data, a unit rating is calculated for each of the units in the roof fall. This unit rating indicates the relative strength of the individual units in the sequence. The next calculation—the roof rating—adds in the properties of the entire bolted sequence to yield the final CMRR.

Individual Discontinuity Rating

One unit rating calculation sheet (figure 13) is used for each of the units in the mine roof sequence. First, the individual discontinuity rating is calculated within the individual unit. The individual discontinuity rating represents the total effect of all of the bed discontinuities on unit strength. This number, as well as the other converted values, is calculated by applying the field data to a series of conversion tables (tables 1-9), then entering the table value on the calculation sheet. The effects of discontinuity cohesion and roughness are combined into a matrix (table 1), and, for example, the combination of weak cohesion and a wavy roughness yields a value of 20. This combination of cohesion and roughness is a measure of the shear strength of the discontinuity surface. The end members of the range for shear strength are a very cohesive, jagged surface (strong) to a slickensided, planar surface (weak).

Discontinuity spacing and persistence are handled similarly with table 2. These two parameters, combined

in this conversion table, represent the intensity of the discontinuity that weakens the unit. This ranges from a closely bedded, very persistent bedding such as in a laminated shale (9) to an unbedded massive rock such as a limestone (35). If a rock has no bedding and is very cohesive (cohesion = strong), then enter a 35 as the highest value in the Spacing-Persistence block on the unit rating calculation sheet.

The sum of cohesion-roughness and spacing-persistence equals the individual discontinuity rating. After the individual discontinuity ratings for each unit are calculated, the lowest of these values is entered in the space next to item (2). This lowest value is used to compute the unit discontinuity rating.

Multiple Discontinuity Adjustment

The individual discontinuity rating also takes into account a second discontinuity in each bed. Multiple discontinuities are known to further weaken the rock. For example, a laminated shale may also have very persistent, angled slickensides as a second discontinuity. The discontinuity that grades out the lowest is the basic rating and is reduced by the second discontinuity. This effect is calculated by using table 3.

Unit Strength

The unit strength rating is calculated by using table 4 and is entered on the unit rating calculation sheet. The highest possible rating for rock strength is 30, which would correspond to a strong limestone or crystalline sandstone (uniaxial compressive strength > 103 MPa (> 15,000 psi)).

Unit Moisture Sensitivity

The last calculation in the unit rating is that of unit moisture sensitivity. This test can be applied to a rock in two ways:

1. Conduct an immersion test;
2. Visually estimate the staining or slaking on the rock surface.

If possible, a small hand sample is immersed in water for 24 h, and its water sensitivity is evaluated (see immersion test data sheet at figure 9). The effects of water absorption, swelling and cracking, and debris suspension are observed, and a determination of the moisture sensitivity is made. If no hand sample is available, then the moisture sensitivity is evaluated by visually observing the amount of oxidation staining on the rock. Table 5 is used to make the conversion of the field moisture sensitivity data to the unit rating calculation sheet.

The CMRR recognizes that it does not matter if a rock is water-sensitive if it is not exposed to moisture. Therefore, even if the rock in question is highly water-sensitive, the moisture sensitivity rating is entered only if the rock forms the immediate mine roof or if it is exposed to groundwater leakage. Thus, the rating system deducts only for water-sensitive rocks that are *exposed* to water.

Lastly, all of the data sheet values are summed to calculate the unit rating. This procedure is repeated on separate sheets for each of the units present.

CMRR CALCULATION

The roof rating calculation sheet generates the final CMRR by applying adjustments to the base unit rating weighted average (figure 19). While the unit rating involves individual unit properties, the adjustments deal with effects on the strength of the whole sequence. Finally, the sum of the RR_w of unit rating and the adjustments comprises the final CMRR.

Thickness-Weighted Average

First, the thickness-weighted average of unit ratings is computed. Consider only the units that fall into the range of the bolted interval. If the bolt extends part way into a unit, use only that part of the unit in which the bolt will be anchored. For example, if you plan to use a 1.8-m (6-ft) bolt in a mine roof composed of 0.9 m (3 ft) of shale and 1.2 m (4 ft) of sandstone, then use both beds as units, but use only 0.9 m (3 ft) of the sandstone as the second unit when entering the bolt interval (BI).

After the thickness-weighted average of unit rating is calculated, the final CMRR is calculated by adding the

adjustments to the thickness-weighted average of all of the units (RR_w).

Adjustments

There are four adjustments to compute the final CMRR. The first adjustment—the strong bed adjustment—is designed to add points to the rating to recognize the added strength value of a significantly strong bed in the bolted interval. It is determined by comparing the largest unit rating of units greater than 30 cm (1 ft) to the weighted average of unit ratings (RR_w). If the difference between the largest unit rating and the RR_w is greater than 5 points and the unit is at least 0.3 m (12 in) thick, then the strong bed adjustment is assigned according to table 6. The value from table 6 may be reduced if the thickness of weak material that must be supported by the strong bed is greater than 0.9 m (3 ft) (see adjustment formula noted beneath table 6).

The unit contacts adjustment is assigned similarly. Total the number of contacts in the bolted interval and determine the adjustment in table 7. For example, if there are three units in the bolted interval, then there are two contacts, yielding a 2-point deduction. Only significant weakness planes are considered.

The groundwater adjustment is based on the water conditions observed in the field and is converted into a deduction using table 8.

The final adjustment is the surcharge adjustment. The surcharge refers to the loads that may be applied to the bolted interval by rocks that may have separated above the bolted interval. Compare the unit ratings of overlying rocks with the weighted average of the strength of the rocks in the bolted interval. If overlying units are significantly less competent than the bolted interval, deduct 2 to 5 points (table 9).

APPENDIX C.—CMRR REFERENCE DATABASE

This appendix represents the current USBM database of CMRR values for U.S. coal mines. These data have been collected from all of the major U.S. coalfields and are intended to serve as a reference for coal mine operators. There are 97 individual cases representing 75 coal mines.

Owing to the wide variation in coal mine roof geology, it is recommended that the mine operator collect field data and calculate the CMRR specific to the operator's area. However, if site-specific data are unavailable, this database can provide an example of the CMRR for a particular coal seam of interest.

Table C-1 presents a summary of the data collected by State, coal seam, CMRR, and individual groundwater

condition. In some cases, generally where conditions are variable, multiple values were calculated for the same mine. These are reflected by the addition of the letters "A," "B," and "C" to the mine ID number. Following table C-1, the complete datasets collected at each mine are presented on the CMRR field data sheets. The CMRR values are calculated for a 1.8-m (72-in) bolt height, but all of the mine roof data are presented for the calculation of larger-bolted intervals. The data are not intended to cover the full range of possible CMRR's for every coalbed or State, but rather reflect the USBM's experience at individual mines. Unit ratings are provided and can be used to construct a CMRR from individual units of different cases.

Table C-1.—CMRR reference database

State	Coal seam	Mine ID	Coal Mine Roof Rating (CMRR)	Groundwater condition ¹
Alabama	Blue Creek	1	47	1
Alabama	.. do.	2	70	1
Colorado	Maxwell	3	42	1
Colorado	D Seam	4	47	1
Colorado	.. do.	5	51	1
Colorado	Wadge	6	72	1
Illinois	Herrin (No 6)	7	85	2
Illinois	.. do.	8	22	2
Illinois	.. do.	9	53	1
Illinois	.. do.	10	69	1
Illinois	.. do.	10A	82	1
Illinois	.. do.	11	61	1
Illinois	.. do.	12	40	1
Illinois	.. do.	12A	42	1
Kentucky	Lower Elkhorn	13	48	1
Kentucky	.. do.	13A	90	1
Kentucky	Hazard No. 4	14	26	2
Kentucky	Wallins Creek	15	58	2
Kentucky	Harlan	16	56	1
Kentucky	Harlan	16A	72	1
Kentucky	Harlan	17	81	1
Kentucky	Harlan	17A	58	1
Kentucky	Alma	18	56	1
Kentucky	Lower Elkhorn	19	48	1
Maryland	Upper Freeport	20	55	1
Maryland	.. do.	20A	42	1
New Mexico	York Canyon	21	31	1
Ohio	Clarion 4A	22	46	1
Ohio	.. do.	23	31	1
Ohio	.. do.	24	24	3
Ohio	Pittsburgh	25	67	1
Ohio	Pittsburgh	25A	45	1
Pennsylvania	Lower Freeport	26	53	3
Pennsylvania	.. do.	26A	40	1
Pennsylvania	.. do.	26B	45	3
Pennsylvania	Lower Kittanning	27	42	2
Pennsylvania	Sewickley	28	48	2
Pennsylvania	Pittsburgh	29	46	1
Pennsylvania	Pittsburgh	30	41	1

See explanatory notes at end of table.

Table C-1.—CMRR reference database—Continued

State	Coal seam	Mine ID	Coal Mine Roof Rating (CMRR)	Groundwater condition ¹
Pennsylvania	Pittsburgh	31	34	1
Pennsylvania	Pittsburgh	32	39	1
Pennsylvania	Pittsburgh	33	44	1
Pennsylvania	Pittsburgh	34	36	1
Pennsylvania	Lower Kittanning	35	48	1
Pennsylvania	Upper Kittanning	36	56	1
Pennsylvania	Sewickley	37	54	1
Pennsylvania	Upper Kittanning	38	53	2
Pennsylvania	.. do.	38A	50	1
Pennsylvania	Upper Freeport	39	33	3
Pennsylvania	.. do.	39A	50	2
Pennsylvania	.. do.	39B	32	3
Pennsylvania	Sewickley	40	46	1
Pennsylvania	Pittsburgh	41	40	1
Pennsylvania	Pittsburgh	42	41	1
Tennessee	Beech Grove	43	49	2
Utah	Castlegate	D44	81	1
Utah	Upper O'Connor	45	65	1
Utah	Hiawatha	46	76	1
Utah	Blind Canyon	47	81	1
Utah	Wattis	48	70	1
Virginia	Dorchester	49	53	1
Virginia	Dorchester	49A	45	1
Virginia	Jawbone	50	65	1
Virginia	Jawbone	50A	54	1
Virginia	Pocahontas No. 3	51	78	1
Virginia	Taggart	52	59	1
Virginia	Lower Banner	53	45	1
West Virginia	Fire Creek	54	73	4
Do.	No. 2 Gas	55	63	1
Do.	.. do.	55A	60	1
Do.	Pittsburgh	56	40	1
Do.	Pittsburgh	57	39	1
Do.	Upper Freeport	58	45	1
Do.	.. do.	58A	78	1
Do.	.. do.	58B	38	2
Do.	.. do.	58C	42	1
Do.	Eagle	59	54	1
Do.	Eagle	59A	44	5
Do.	Cedar Grove	60	40	1
Do.	.. do.	60A	48	1
Do.	Eagle	61	55	1
Do.	Campbell Creek	62	52	1
Do.	.. do.	63	38	1
Do.	Alma	64	63	3
Do.	Beckley	65	53	2
Do.	Lower Kittanning	66	31	1
Do.	Coalburg	67	96	1
Do.	Coalburg	67A	53	2
Do.	Coalburg	68	43	1
Do.	Stockton	69	75	1
Do.	Lower Cedar Grove	70	36	2
Do.	Coalburg	71	74	2
Do.	Pocahontas No. 4	72	60	2
Do.	Upper Freeport	73	39	1
Do.	.. do.	73A	39	2
Do.	.. do.	73B	66	1
Wyoming	Hanna	74	37	1

Do. Same as above.

¹1 = Dry; 2 = damp; 3 = light drip; 4 = heavy drip; and 5 = flowing.

DATE _____ MINE 1 LOCATION ALABAMA PAGE 1 OF 1 CMRR 47
 COAL SEAM BLUE CREEK NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
5	30 in		Sandstone	1	1	A.	No information	3	2.5	2	3			73
						B.								
						C.								
CONTACT														
4	24 in		Siltstone	3	1	A.	Bedding	1	1	1	1			66
						B.	Joints	3	3	1	1			
						C.								
CONTACT														
3	12 in		Coal	4	1	A.	No information	3.5	1.5	4	4			38
						B.								
						C.								
CONTACT														
2	18 in		Rash	3.5	1	A.	Laminations	1	2	5	1			44
						B.								
						C.								
CONTACT														
1	36 in		Underclay	3.5	1	A.	Sips	3.5	2.5	1.5	4			57
						B.								
						C.								

DATE _____ MINE 2 LOCATION ALABAMA PAGE 1 OF 1 CMRR 70
 COAL SEAM BLUE CREEK NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2	24 in		Sandstone	1	1	A.	No information	3	2.5	2	3			73
						B.								
						C.								
CONTACT														
1	24 in		Siltstone	3	1	A.	Bedding	1	1	1	1			66
						B.	Joints	3	3	1	1			
						C.								

DATE _____ MINE 3 LOCATION COLORADO PAGE 1 OF 1 CMRR 42

COAL SEAM MAXWELL NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco ID	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3	24 in		Drawrock	3.5	1	A	Sicks	4	2	4	1			40
						B								
						C								
CONTACT														
2	36 in		Shale	3	1	A	Bedding	3	3	1	2			50
						B	Joints	3	3	2	2			
						C								
CONTACT														
1	60 in		Drawrock	3.5	1	A	Sicks	4	2	4	1			40
						B								
						C								

DATE _____ MINE 4 LOCATION COLORADO PAGE 1 OF 1 CMRR 47

COAL SEAM D SEAM NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco ID	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3	48 in		Siltstone	3	1	A	No information	3	2.5	2	3			58
						B								
						C								
CONTACT														
2	12 in		Coal	4	1	A	No information	3.5	1.5	4	4			38
						B								
						C								
CONTACT														
1	48 in		Mudstone, carbonaceous	3	1	A	Sicks	4	2.5	5	4			34
						B								
						C								

DATE _____ MINE 5 LOCATION COLORADO PAGE 1 OF 1 CMRR 51

COAL SEAM D SEAM NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip	
5						A.							
						B.							
						C.							
CONTACT													
4	48 in		Siltstone	3	1	A.	No information	3	2.5	2	3		58
						B.							
						C.							
CONTACT													
3	24 in		Mudstone, carbonaceous	3	1	A.	No information	4	2.5	5	4		34
						B.							
						C.							
CONTACT													
2	48 in		Siltstone	2	1	A.	Joints	2	1	4	1.5		60
						B.							
						C.							
CONTACT													
1	12 in		Mudstone, carbonaceous	3	1	A.	No information	4	2.5	5	4		34
						B.							
						C.							

DATE _____ MINE 6 LOCATION COLORADO PAGE 1 OF 1 CMRR 72

COAL SEAM VADGE NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip	
3						A.							
						B.							
						C.							
CONTACT													
2	72 in		Siltstone	2	1	A.	No information	3	2.5	2	3		65
						B.							
						C.							
CONTACT													
1	36 in		Shale	3.5	1	A.	Lamination	1	1	4	4		62
						B.	Joints	1	1	4	4		
						C.							

DATE _____ MINE 7 LOCATION ILLINOIS PAGE 1 OF 1 CMRR 85

COAL SEAM HERRIN NO. 6 NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation		
												Strike		Dip
3	360 in		Sandstone	1.5	2	A.	Bedding	1.5	3	3	4			77
						B.								
						C.								
CONTACT														
2	72 in		Limestone	1.5	1	A.	Bedding	1	1	1	1			96
						B.								
						C.								
CONTACT														
1	24 in		Shale	4	2	A.	Bedding	4	3	4	2			27
						B.	Jant	3	3	5	4			
						C.								

DATE _____ MINE 8 LOCATION ILLINOIS PAGE 1 OF 1 CMRR 22

COAL SEAM HERRIN NO. 6 NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation		
												Strike		Dip
3						A.								
						B.								
						C.								
CONTACT														
2	180 in		Shale	4	2	A.	Bedding	3	3	4	4			36
						B.								
						C.								
CONTACT														
1	66 in		Shale	4	3	A.	Bedding	3	3	5	4			25
						B.								
						C.								

DATE _____ MINE 9 LOCATION ILLINOIS PAGE 1 OF 1 CMRR 53

COAL SEAM HERRIN NO. 6 NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2						A.								
						B.								
						C.								
CONTACT														
1	300 in		Shale, gray	3	1	A.	Shears	3.5	2	2	3			53
						B.	Bedding	3	3	2	2.5			
						C.								

DATE _____ MINE 10 LOCATION ILLINOIS PAGE 1 OF 1 CMRR 69

COAL SEAM HERRIN NO. 6 NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3	48 in		Limestone	1	1	A.	Joints	2	3	1	4			85
						B.								
						C.								
CONTACT														
2	38 in		Shale, black	3	1	A.	Joints	3	3	4	3			42
						B.	Bedding	3	2	2.5	4			
						C.								
CONTACT														
1	24 in		Shale, gray	3	1	A.	Shears	3	2	2	3			60
						B.	Bedding	1	1	1	1			
						C.								

DATE _____ MINE _____ 10A _____ LOCATION ILLINOIS _____ PAGE 1 OF 1 CMRR 82

COAL SEAM HERRIN NO. 6 _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2	60 in		Limestone	7	7	A.	Joints	2	3	2	1			85
						B.								
						C.								
CONTACT														
1	36 in		Shale, black	3	7	A.	Joints	3	2	4	3			42
						B.	Bedding	3	2	2.5	2			
						C.								

DATE _____ MINE _____ 11 _____ LOCATION ILLINOIS _____ PAGE 1 OF 1 CMRR 61

COAL SEAM HERRIN NO. 6 _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2	120 in		Shale, gray	3	7	A.	Joints	2	3	3	3			65
						B.	Bedding	2	3	4	1			
						C.								
CONTACT														
1	8 in		Coal	4	7	A.	No information	2	2	4	3			50
						B.								
						C.								

DATE _____ MINE 12 LOCATION ILLINOIS PAGE 1 OF 1 CMRR 40

COAL SEAM HERRIN NO. 6 NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2						A.								
						B.								
						C.								
CONTACT														
1	96 in		Shale, weak with coal streaks	3	3	A.	Bedding	3	2	5	1			40
						B.	Joints	3	1	4	2			
						C.								

DATE _____ MINE 12A LOCATION ILLINOIS PAGE 1 OF 1 CMRR 42

COAL SEAM HERRIN NO. 6 NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2	60 in		Shale	3	4	A.	Bedding	2	3	5	4			47
						B.	Joint	3	3	2	1			
						C.								
CONTACT														
1	36 in		Shale, grey	3	3	A.	Bedding	2	3	5	4			40
						B.	Joints	2	3	2	1			
						C.	Joints	2	3	2	1			

DATE _____ MINE _____ 14 _____ LOCATION _____ KENTUCKY _____ PAGE 1 OF 1 CMRR 26

COAL SEAM _____ HAZARD NO. 4 _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2	480 in		Sandstone	2	1	A.	Crossbed	1	3	4	3			72
						B.	Bedding	2	3	2	4			
						C.								
CONTACT														
1	72 in		Shale, fossils	4	2	A.	Bedding	3	3	3	3			28
						B.	Bedding	3	3	5	3			
						C.								

DATE _____ MINE _____ 15 _____ LOCATION _____ KENTUCKY _____ PAGE 1 OF 1 CMRR 58

COAL SEAM _____ WALLINS _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2						A.								
						B.								
						C.								
CONTACT														
1	120 in		Shale, fossils	3	3.5	A.	Bedding	2	3	1	4			60
						B.								
						C.								

DATE _____ MINE _____ 16 _____ LOCATION _____ KENTUCKY _____ PAGE 1 OF 1 CMRR 56

COAL SEAM _____ HARLAN _____ NAME _____

UNIT						UNIT DISCONTINUITIES								Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip			
3						A.									
						B.									
						C.									
CONTACT															
2	84 in		Sandstone	15	7	A.	Crossbed	3	3	4	7			59	
						B.									
						C.									
CONTACT															
1	36 in		Shale	3	7	A.	Sicks	4	2	4.5	4			36	
						B.									
						C.									

DATE _____ MINE _____ 16A _____ LOCATION _____ KENTUCKY _____ PAGE 1 OF 1 CMRR 72

COAL SEAM _____ HARLAN _____ NAME _____

UNIT						UNIT DISCONTINUITIES								Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip			
3						A.									
						B.									
						C.									
CONTACT															
2						A.									
						B.									
						C.									
CONTACT															
1	180 in		Sandstone	2	7	A.	Weak plane	3	2	2	7			72	
						B.									
						C.									

DATE _____ MINE 17 LOCATION KENTUCKY PAGE 1 OF 1 CMRR 81

COAL SEAM HARLAN NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating		
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip			
3						A.									
						B.									
						C.									
CONTACT															
2	84 in		Sandstone	1	1	A.	Bedding	1.5	1	2	3			85	
						B.									
						C.									
CONTACT															
1	36 in		Shale	2.5	1	A.	Joints	2	3	1	2			72	
						B.	Bedding	1.5	1	2	3				
						C.									

DATE _____ MINE 17A LOCATION KENTUCKY PAGE 1 OF 1 CMRR 58

COAL SEAM HARLAN NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating		
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip			
3						A.									
						B.									
						C.									
CONTACT															
2						A.									
						B.									
						C.									
CONTACT															
1	360 in		Shale	2.5	1	A.	Bedding	2	3	4	2			63	
						B.									
						C.									

DATE _____ MINE _____ 18 _____ LOCATION _____ KENTUCKY _____ PAGE 1 OF 1 CMRR 56
 COAL SEAM _____ ALMA _____ NAME _____

UNIT						UNIT DISCONTINUITIES								Unit Rating
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. ID	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation		
												Strike	Dip	
3						A.								
						B.								
						C.								
	CONTACT													
2						A								
						B.								
						C.								
	CONTACT													
1	240 in		Stack rock	3	1	A	Minor bedding	2	1	4	3			56
						B	Major bedding	2	3	3	3			
						C								

DATE _____ MINE _____ 19 _____ LOCATION _____ KENTUCKY _____ PAGE 1 OF 1 CMRR 48
 COAL SEAM _____ LOWER ELKHORN _____ NAME _____

UNIT						UNIT DISCONTINUITIES								Unit Rating
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. ID	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation		
												Strike	Dip	
3						A								
						B								
						C								
	CONTACT													
2						A								
						B								
						C								
	CONTACT													
1	120 in		Stack rock	2	1	A	Bedding	3	5	3	4	4		48
						B								
						C								

DATE _____ MINE 20 _____ LOCATION MARYLAND _____ PAGE 1 OF 1 CMRR 55

COAL SEAM UPPER FREEPORT _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2	80 in		Sandstone	1.5	1	A.	No information	3	2.5	1	2			80
						B.								
						C.								
CONTACT														
1	60 in		Shale	3	1	A.	Laminations	4	3	5	1			32
						B.	Joints	3.5	3	2	2			
						C.								

DATE _____ MINE 20A _____ LOCATION MARYLAND _____ PAGE 1 OF 1 CMRR 42

COAL SEAM UPPER FREEPORT _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3	30 in		Shale, grey	3	1	A.	Bedding	3	3	5	1			44
						B.								
						C.								
CONTACT														
2	37 in		Stackrock	2.25	1	A.	Bedding	3	3	5	1			42
						B.								
						C.								
CONTACT														
1	35 in		Shale, black	2.5	2	A.	Bedding	3	3	5	4			44
						B.								
						C.								

DATE _____ MINE _____ 21 _____ LOCATION _____ NEW MEXICO _____ PAGE 1 OF 1 CMRR 31
 COAL SEAM _____ YORK CANYON _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco ID	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation		
												Strike		Dip
3	in					A								
						B								
						C								
CONTACT														
2						A								
						B								
						C								
CONTACT														
1	180 in		Claystone	4	1	A	Sacks	4	3	4	3			31
						B	Bedding	3	2	3	3			
						C								

DATE _____ MINE _____ 22 _____ LOCATION _____ OHIO _____ PAGE 1 OF 1 CMRR 46
 COAL SEAM _____ CLARTON 4A _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco ID	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation		
												Strike		Dip
5						A								
						B								
						C								
CONTACT														
4	96 in		Siltstone, slabby, limestone, nodules	4	3	A	Bedding	2	2	5	1			42
						B	Limestone nodules	2	1.5	5	2			
						C								
CONTACT														
3	8 in		Coal rash, soft	4	5	A	Bedding	3.5	2	5	2			34
						B								
						C								
CONTACT														
2	12 in		Limestone, hard bulbous fossils	1	1	A	Intact rock	1	1	1	1			100
						B								
						C								
CONTACT														
1	6 in		Coal rash, soft	5	5	A	Bedding	3.5	2	5	2			29
						B								
						C								

DATE _____ MINE _____ 23 _____ LOCATION _____ OHIO _____ PAGE 1 OF 1 CMRR 31

COAL SEAM _____ CLARION 4A _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3	36 in		Claystone, extremely weak slicks	5	5	A	Slicks	4	2	5	2			29
						B								
						C								
CONTACT														
2	72 in		Limestone, massive with nodules	7	7	A	Nodules	2	15	2	3			83
						B								
						C								
CONTACT														
1	72 in		Shale, laminated with coal streaks	4	4	A	Bedding	3	3	5	3			31
						B	Slips	4	2	2	3			
						C								

DATE _____ MINE _____ 24 _____ LOCATION _____ OHIO _____ PAGE 1 OF 1 CMRR 24

COAL SEAM _____ CLARION 4A _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3	>		Sandstone, roof of fall	7	2	A	Bedding	3	3	3	3			
						B								
						C								
CONTACT														
2	48 in		Claystone, weathered	4	3	A	Bedding	3	3	5	2			27
						B	Joints	35	3	3	2			
						C								
CONTACT														
1	60 in		Sandstone, clay stringers coal streaks	3	3	A	Bedding	3	25	5	4			32
						B	Coal streaks	2	1	2	2			
						C								

DATE _____ MINE _____ 25 _____ LOCATION OHIO _____ PAGE 1 OF 1 CMRR 67

COAL SEAM PITTSBURGH _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2	36 in		Limestone, massive	1	1	A.	Intact	1	1	1	4			100
						B.								
						C.								
CONTACT														
1	48 in		Claystone, weak, slickensided	5	4	A.	Sicks	3	2	5	1			30
						B.	Bedding	3	1.5	5	1			
						C.								

DATE _____ MINE _____ 25A _____ LOCATION OHIO _____ PAGE 1 OF 1 CMRR 45

COAL SEAM PITTSBURGH _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2	36 in		Limestone, with clay stringers	3	2	A.	Bedding	2	2	3	2			63
						B.								
						C.								
CONTACT														
1	48 in		Claystone, soft with limestone nodules	5	3	A.	Sicks	3	1.5	5	1			32
						B.	Bedding	3	1	5	4			
						C.								

DATE _____ MINE 26 LOCATION PENNSYLVANIA PAGE 1 OF 1 CMRR 53

COAL SEAM LOWER FREEPORT NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3	38 in		Shale, platy	4	1	A.	Bedding	3	3	5	4			35
						B.								
						C.								
CONTACT														
2	24 in		Sandstone	1.5	1	A.	Bedding	1.5	3	3.5	4			73
						B.	Cross bedding	1.5	3	3	4			
						C.								
CONTACT														
1	36 in		Shale, platy with sandstone stringers	3	1	A.	Bedding	3	3	5	4			40
						B.								
						C.								

DATE _____ MINE 26A LOCATION PENNSYLVANIA PAGE 1 OF 1 CMRR 40

COAL SEAM LOWER FREEPORT NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2						A.								
						B.								
						C.								
CONTACT														
1	144 - in		Shale, platy	3	1	A.	bedding	3	3	5	3			40
						B.								
						C.								

DATE _____ MINE 26B LOCATION PENNSYLVANIA PAGE 1 OF 1 CMRR 45

COAL SEAM LOWER FREEPORT NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3	36 in		Shale	3.5	1	A.	Bedding	3	3	4	4			28
						B.								
						C.								
CONTACT														
2	38 in		Sandstone, cross bedding	2	1	A.	Bedding	3	2.5	3	4			56
						B.	Cross bedding	3	2.5	3	4			
						C.								
CONTACT														
1	52 in		Shale	3	1	A.	Beds	3	3	4.5	4			42
						B.								
						C.								

DATE _____ MINE 27 LOCATION PENNSYLVANIA PAGE 1 OF 1 CMRR 42

COAL SEAM LOWER KITTANNING NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2	42 in		Cleystone, slickensided	5	3	A.	Intact rock	4	2	5	1			14
						B.								
						C.								
CONTACT														
1	84 in		Shale, sandy	4	1.5	A.	Bedding	2	3	4	1			50
						B.								
						C.								

DATE _____ MINE _____ 28 _____ LOCATION PENNSYLVANIA _____ PAGE 1 OF 1 CMRR 48

COAL SEAM SEWICKLEY _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2	84 in		Stackrock	2	1	A.	Bedding	3	2	4	4			55
						B.								
						C.								
CONTACT														
1	72 in		Shale	3	1	A.	Bedding	3	2	4	4			48
						B.								
						C.								

DATE _____ MINE _____ 29 _____ LOCATION PENNSYLVANIA _____ PAGE 1 OF 1 CMRR 46

COAL SEAM PITTSBURGH _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
5	120 in		Shale	3.5	1	A.	Laminations	2	3	5	1.5			47
						B.								
						C.								
CONTACT														
4	4 in		Sandstone	1.5	1	A.	No information	1	1	1	1			98
						B.								
						C.								
CONTACT														
3	18 in		Shale	3.5	1	A.	Laminations	2	3	5	1.5			47
						B.								
						C.								
CONTACT														
2	6 in		Coal	4	1	A.	Laminations	2	1.5	4	4			51
						B.								
						C.								
CONTACT														
1	48 in		Shale	3.5	1	A.	Laminations	2	3	5	1.5			47
						B.	Joints	2	3	1	4			
						C.								

DATE _____ MINE 30 LOCATION PENNSYLVANIA PAGE 1 OF 1 CMRR 41

COAL SEAM PITTSBURGH NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2	240 in		Shale	3	1	A.	Laminations	3	3	4.5	1			44
						B.	Joints	1	3	3	4			
						C.								
CONTACT														
1	6 in		Drawrock	3.5	1	A.	Disco	4	2.5	5	3			34
						B.								
						C.								

DATE _____ MINE 31 LOCATION PENNSYLVANIA PAGE 1 OF 1 CMRR 34

COAL SEAM PITTSBURGH NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
E						A.								
						B.								
						C.								
CONTACT														
4	48 in		Shale	3	1	A.	Bedding	3	3	4	2			46
						B.	Laminations	1	1	1	1			
						C.								
CONTACT														
3	60 in		Resh	3	1	A.	Bedding	3	3	4	2			36
						B.	Sicks	4	3	4	4			
						C.								
CONTACT														
2	8 in		Drawrock	4	1	A.	Sicks	4	1	5	4			29
						B.								
						C.								
CONTACT														
1	6 in		Coal	4	1	A.	No information	2	1.5	4	4			46
						B.								
						C.								

DATE _____ MINE _____ 32 _____ LOCATION PENNSYLVANIA _____ PAGE 1 OF 1 CMRR 39

COAL SEAM PITTSBURGH _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3	120 in		Shale	3	1	A.	Laminations	3	3	5	2			40
						B.								
						C.								
CONTACT														
2	24 in		Coal	4	1	A.	Cleat	3	1.5	4	4			45
						B.								
						C.								
CONTACT														
1	36 in		Shale	3	1	A.	Laminations	3	3	5	2			40
						B.								
						C.								

DATE _____ MINE _____ 33 _____ LOCATION PENNSYLVANIA _____ PAGE 1 OF 1 CMRR 44

COAL SEAM PITTSBURGH _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2	40 in		Resh	3.5	1	A.	Bedding	3	3	3	1			48
						B.	Joints	3	1	4	4			
						C.								
CONTACT														
1	12 in		Coal	4	1	A.	No information	3	1.5	4	4			42
						B.								
						C.								

DATE _____ MINE 34 LOCATION PENNSYLVANIA PAGE 1 OF 1 CMRR 36

COAL SEAM PITTSBURGH NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
5						A.								
						B.								
						C.								
	CONTACT													
4	36 in		Resh	3.5	1	A.	Bedding	3	3	3	1			36
						B.	Laminations	3	3	5	4			
						C.								
	CONTACT													
3	18 in		Coal	4	1	A.	No information	3	1.5	4	4			42
						B.								
						C.								
	CONTACT													
2	12 in		Drawrock	3	1	A.	Shears	4	2.5	5	1			29
						B.	Bedding	3	2.5	5	1			
						C.								
	CONTACT													
1	6 in		Coal	4	1	A.	No information	3	1.5	4	4			42
						B.								
						C.								

DATE _____ MINE 35 LOCATION PENNSYLVANIA PAGE 1 OF 1 CMRR 46

COAL SEAM LOWER KITTANNING NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
	CONTACT													
2						A.								
						B.								
						C.								
	CONTACT													
1	180 in		Shale	3	1	A.	Laminations	3	3	4	1			48
						B.	Shale	3	3	1	1			
						C.								

DATE _____ MINE 36 LOCATION PENNSYLVANIA PAGE 1 OF 1 CMRR 56

COAL SEAM UPPER KITTANNING NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
	CONTACT													
2						A.								
						B.								
						C.								
	CONTACT													
1	14.4 in		Sandstone and shale	2	1	A.	Bedding	3	1.5	4.5	2			56
						B.	Joints	3	1	1	2			
						C.								

DATE _____ MINE 37 LOCATION PENNSYLVANIA PAGE 1 OF 1 CMRR 54

COAL SEAM SEWICKLEY NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
	CONTACT													
2						A.								
						B.								
						C.								
	CONTACT													
1	60 in		Shale, laminated	2	1	A.	Coal streaks	3	3	1	2			54
						B.	Joints	3	2	1	1			
						C.	Bedding	2	3	5	4			

DATE _____ MINE 38 LOCATION PENNSYLVANIA PAGE 1 OF 1 CMRR 53

COAL SEAM UPPER KITTANNING NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco ID	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A								
						B								
						C								
CONTACT														
2	36 in		Shale, highly jointed	2.5	1	A	Joints	2	2	4	1			59
						B	Joints	2	3	4	1			
						C								
CONTACT														
1	6 in		Rider coal, drawrock	4	2	A	Clear	3	3	5	2			27
						B	Bedding	3	3	5	2			
						C								

DATE _____ MINE 38A LOCATION PENNSYLVANIA PAGE 1 OF 1 CMRR 50

COAL SEAM UPPER KITTANNING NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco ID	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A								
						B								
						C								
CONTACT														
2	36 in		Shale, closely spaced joints	1	1	A	Bedding	2	2	5	2			60
						B	Joints	2	3	5	1			
						C								
CONTACT														
1	11 in		Rider coal, drawrock	4	2	A	Bedding	3	2	5	4			31
						B	Clear	3	2	5	4			
						C								

DATE _____ MINE 39 LOCATION PENNSYLVANIA PAGE 1 OF 1 CMRR 33

COAL SEAM UPPER FREEPORT NAME _____

UNIT						UNIT DISCONTINUITIES								Unit Rating
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2						A.								
						B.								
						C.								
CONTACT														
1	96 in		Shale, highly laminated	3	2	A.	Bedding	3	3	5	4			37
						B.								
						C.								

DATE _____ MINE 39A LOCATION PENNSYLVANIA PAGE 1 OF 1 CMRR 50

COAL SEAM UPPER FREEPORT NAME _____

UNIT						UNIT DISCONTINUITIES								Unit Rating
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2						A.								
						B.								
						C.								
CONTACT														
1	96 in		Shale, massive with sandstone streaks	2.5	2	A.	Laminations	7	3	5	4			52
						B.	Bedding	3	3	3	4			
						C.								

DATE _____ MINE 39B LOCATION PENNSYLVANIA PAGE 1 OF 1 CMRR 32
 COAL SEAM UPPER FREEPORT NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3	8 in		Fault gouge	5	3	A.	Shears	4	3	5	1			14
						B.								
						C.								
CONTACT														
2	42 in		Shale, with thin clay beds	3	2	A.	Bedding	3	2	5	2			41
						B.								
						C.								
CONTACT														
1	12 in		Shale	3	3	A.	Bedding	3	3	5	2			30
						B.								
						C.								

DATE _____ MINE 40 LOCATION PENNSYLVANIA PAGE 1 OF 1 CMRR 46
 COAL SEAM SEVICKLEY NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2						A.								
						B.								
						C.								
CONTACT														
1	72 in		Shale, highly jointed, weak, fossils	4	2	A.	Bedding	2	3	4	3			46
						B.	Joint	2	3	3	3			
						C.	Joint	2	3	3	3			

DATE _____ MINE _____ 41 _____ LOCATION PENNSYLVANIA _____ PAGE 1 OF 1 CMRR 40

COAL SEAM PITTSBURGH _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert.	Orientation Strike		Dep.
3						A.								
						B.								
						C.								
CONTACT														
2	14 in		Shale	3.5	1	A.	Bedding	4	2	2	2			50
						B.								
						C.								
CONTACT														
1	58 in		Rider coal, shale, head coal	4	1	A.	Bedding	3	3	5	3			33
						B.	Crest	2	3	4	1			
						C.								

DATE _____ MINE _____ 42 _____ LOCATION PENNSYLVANIA _____ PAGE 1 OF 1 CMRR 41

COAL SEAM PITTSBURGH _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert.	Orientation Strike		Dep.
3						A.								
						B.								
						C.								
CONTACT														
2	36 in		Shale	2	2	A.	Bedding	2	5	5	2			46
						B.	Shears	4	2	3	2			
						C.								
CONTACT														
1	36 in		Rider coal - 16 in Shale - 8 in Top coal - 12 in	3	1	A.	Bedding	3	3	5	2			35
						B.	Crest	3	2	5	2			
						C.								

DATE _____ MINE _____ 43 _____ LOCATION TENNESSEE _____ PAGE 1 OF 1 CMRR 49

COAL SEAM BEECH GROVE _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3	480 in		Shale/sandstone	3	2	A.	Bedding	2	3	4	4			50
						B.								
						C.								
CONTACT														
2	4 in		Shale/coal	4.5	3.5	A.	Bedding	3.5	3	5	2			72
						B.								
						C.								
CONTACT														
1	8 in		Sandstone	1.5	1	A.	Bedding	1	1	1	1			96
						B.								
						C.								

DATE _____ MINE _____ 44 _____ LOCATION UTAH _____ PAGE 1 OF 1 CMRR 81

COAL SEAM CASTLEGATE "D" _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2	72 in		Stackrock	2	1	A.	Bedding	1	1	1	1			85
						B.								
						C.								
CONTACT														
1	12 in		Mudstone	3	1	A.	Shears	3	2	4	2			50
						B.								
						C.								

DATE _____ MINE _____ 45 LOCATION UTAH PAGE 1 OF 1 CMRR 65

COAL SEAM UPPER O'CONNOR NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating		
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco ID	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip			
5						A									
						B									
						C									
CONTACT															
4	60 in		Siltstone	1	1	A	Bedding	3	3	3	1			68	
						B	Joints	3	3	3	1				
						C									
CONTACT															
3	72 in		Sandstone	1.5	1	A	Crossbeds	3	3	2.5	2			60	
						B									
						C									
CONTACT															
2	60 in		Siltstone	1	1	A	Bedding	3	3	3	1			68	
						B	Joints	3	3	3	1				
						C									
CONTACT															
1	12 in		Mudstone, carbonaceous	3	1	A	Disturbed	3.5	2	5	2			39	
						B									
						C									

DATE _____ MINE _____ 46 LOCATION UTAH PAGE 1 OF 1 CMRR 76

COAL SEAM HIAWATHA NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco ID	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A								
						B								
						C								
CONTACT														
2						A								
						B								
						C								
CONTACT														
1	108		Shale	2	1	A	Laminations	1	1	1	1			76
						B	Joints	3	1.5	1	2			
						C								

DATE _____ MINE 47 LOCATION UTAH PAGE 1 OF 1 CMRR 81

COAL SEAM BLIND CANYON NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dep		
3						A.								
						B.								
						C.								
CONTACT														
2	36 in		Sandstone	1	1	A.	Joints	15	1	1	2			96
						B.								
						C.								
CONTACT														
1	36 in		Mudstone, carbonaceous	3	1	A.	No information	3	2	4	2			50
						B.								
						C.								

DATE _____ MINE 48 LOCATION UTAH PAGE 1 OF 1 CMRR 70

COAL SEAM WATTIS NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dep		
3						A.								
						B.								
						C.								
CONTACT														
2	120 in		Sandstone	1	1	A.	No information	3	25	2	3			73
						B.								
						C.								
CONTACT														
1	60 in		Mudstone	2	1	A.	Joint	3	3	1	2			67
						B.	Shears	2	2	3	3			
						C.								

DATE _____ MINE 49 LOCATION VIRGINIA PAGE 1 OF 1 CMRR 53

COAL SEAM DORCHESTER NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2	240 in		Sandstone	2	1	A	Bedding	3	3	5	1			45
						B.	Shears	3	1.75	3	3.5			
						C.								
CONTACT														
1	72 in		Shale	3	1	A	Major bedding	3	3	3	1			53
						B.	Minor bedding	1	1	1	1			
						C.	Shears	3	1	2	3			

DATE _____ MINE 49A LOCATION VIRGINIA PAGE 1 OF 1 CMRR 45

COAL SEAM DORCHESTER NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A								
						B								
						C								
CONTACT														
2						A								
						B								
						C								
CONTACT														
1	240 in		Sandstone	2	1	A	Bedding	3	2	5	1			45
						B.	Shears	3	1.75	3	3.5			
						C								

DATE _____ MINE 50 LOCATION VIRGINIA PAGE 1 OF 1 CMRR 65

COAL SEAM JAWBONE NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A								
						B								
						C								
CONTACT														
2						A								
						B								
						C								
CONTACT														
1	120 in		Sandstone	7	7	A	Crossbeds	3.5	2.5	2.5	7			65
						B	Shears	7	2	2.5	7			
						C	Bedding	1	1	2	7			

DATE _____ MINE 50A LOCATION VIRGINIA PAGE 1 OF 1 CMRR 54

COAL SEAM JAWBONE NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3	120 in		Sandstone	1	1	A	Crossbed	3.5	2.5	2	3			67
						B	Shears	3	1.25	2.5	3			
						C	Bedding	3	3	2	7			
CONTACT														
2	36 in		Siltstone	2	1	A	Shears	3	1.5	3	3			64
						B								
						C								
CONTACT														
1	48 in		Shale	3	1	A	Bedding	3	2.5	3.5	7			52
						B	Shear	3	1.5	3	2			
						C								

DATE _____ MINE 51 LOCATION VIRGINIA PAGE 1 OF 1 CMRR 78

COAL SEAM POCAHONTAS NO. 3 NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip	
5						A							
						B							
						C							
CONTACT													
4	48 in		Siltstone	2	1	A	Bedding	1	1	1	1		
						B							
						C							
CONTACT													
3	6 in		Draystone	3	1	A	Bedding	4	3	5	1		
						B							
						C							
CONTACT													
2	12 in		Siltstone	2	1	A	Bedding	1	1	1	1		
						B							
						C							
CONTACT													
1	6 in		Drayrock	3	1	A	Bedding	4	3	5	1		
						B							
						C							

DATE _____ MINE 52 LOCATION VIRGINIA PAGE 1 OF 1 CMRR 59

COAL SEAM TAGGART NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip	
3	12 in		Sandstone	2	1	A	No information	3	2.5	2	3		
						B							
						C							
CONTACT													
2	90 in		Shale	3	1	A	Laminations	3	2	5	2		
						B							
						C							
CONTACT													
1	26 in		Sandstone	2	1	A	Joints	3	2	2	2		
						B	Crossbeds	3	2	2	2		
						C							

DATE _____ MINE 53 LOCATION VIRGINIA PAGE 1 OF 1 CMRR 45
 COAL SEAM LOWER BANNER NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. ID	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3	24 in		Shale	3	1	A.	Bedding	4	1	4	1			42
						B.								
						C.								
CONTACT														
2	12 in		Coal	4	1	A.	No information	4	1.5	4	4			33
						B.								
						C.								
CONTACT														
	80 in		Shale	3	1	A.	Bedding	4	3	2	1			50
						B.	Shears	3	1	4	4			
						C.	Joints	1	1	1	1			

DATE _____ MINE 54 LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 73
 COAL SEAM FIRE CREEK NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. ID	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2						A.								
						B.								
						C.								
CONTACT														
1	288 in		Sandstone	1	1	A.	Crossbeds	2.5	3	1	3			80
						B.	Bedding	1.5	3	3	4			
						C.								

DATE _____ MINE _____ 55 _____ LOCATION WEST VIRGINIA _____ PAGE 1 OF 1 CMRR 63

COAL SEAM NO. 2 GAS _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A								
						B								
						C								
	CONTACT													
2						A								
						B								
						C								
	CONTACT													
1	120 in		Shale	3	1	A	Bedding	3	25	2	1			63
						B								
						C								

DATE _____ MINE _____ 55A _____ LOCATION WEST VIRGINIA _____ PAGE 1 OF 1 CMRR 60

COAL SEAM NO. 2 GAS _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A								
						B								
						C								
	CONTACT													
2						A								
						B								
						C								
	CONTACT													
1	120 in		Sandstone	2	1	A	Bedding	2	1	5	1			60
						B								
						C								

DATE _____ MINE 56 LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 40

COAL SEAM PITTSBURGH NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
5						A.								
						B.								
						C.								
CONTACT														
4	36 in		Shale	3	7	A.	Laminations	3	3	4	2			48
						B.								
						C.								
CONTACT														
3	18 in		Coal	4	1	A.	No information	3	1.5	4	4			42
						B.								
						C.								
CONTACT														
2	24 in		Shale	3	1	A.	Fractures	3	1	5	4			32
						B.	Bedding	4	2	4.5	4			
						C.								
CONTACT														
1	6 in		Coal	4	1	A.	No information	3	1.5	4	4			42
						B.								
						C.								

DATE _____ MINE 57 LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 39

COAL SEAM PITTSBURGH NAME _____

UNIT						UNIT DISCONTINUITIES								Unit Rating
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
5						A.								
						B.								
						C.								
CONTACT														
4	24 in		Shale	3	1	A.	Laminations	3	3	4	2			46
						B.								
						C.								
CONTACT														
3	36 in		Resh	3.5	1	A.	Sicks	3	3	4	2			40
						B.	Bedding	3	3	4	2			
						C.								
CONTACT														
2	24 in		Coal	4	1	A.	Bedding	3	1.5	4	4			45
						B.								
						C.								
CONTACT														
1	12 in		Drawrock	3.5	1	A.	Sicks	4	2.5	4.5	3			36
						B.								
						C.								

DATE _____ MINE 58 LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 45
 COAL SEAM UPPER FREEPORT NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert.	Orientation Strike Dip		
3	84 in		Shale, sandy bedding, thin	3	1	A.	Bedding	3	3	5	2			40
						B.								
						C.								
CONTACT														
2	30 in		Sandstone with shale streaks	2	1	A.	Bedding	3	3	5	3			45
						B.	Ripples	2.5	2	3	1			
						C.								
CONTACT														
1	64 in		Shale, coarsens to sandy shale	3	2	A.	Bedding	2	3	5	2			47
						B.	Coal spers	3	2	1	1			
						C.								

DATE _____ MINE 58A LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 78
 COAL SEAM UPPER FREEPORT NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert.	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2	240 in		Sandstone, dirty, massive	2	2	A.	Intact rock	1	7	1	1			92
						B.								
						C.								
CONTACT														
1	34 in		Shale, finely laminated	3	1	A.	Bedding	3	3	5	2			40
						B.								
						C.								

DATE _____ MINE 588 LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 38

COAL SEAM UPPER FREEPORT NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
	CONTACT													
2	36+ in		Sandstone, gray wacky, massive	2	2	A.	Intact rock	1	1	1	1			89
						B.								
						C.								
	CONTACT													
1	100 in		Shale, alternating with sandstone	3.5	1	A.	Bedding	2.5	3	5	4			40
						B.	Sandstone ripples	2.5	2	3	2			
						C.								

DATE _____ MINE 58C LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 42

COAL SEAM UPPER FREEPORT NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3	72 in		Shale	3.2	1	A.	No information	4	3	5	1			
						B.								
						C.								
	CONTACT													
2	12 in		Sandstone	1	1	A.	No information	3	2.5	1	2			80
						B.								
						C.								
	CONTACT													
1	60 in		Shale	3.2	1	A.	Laminations	3.5	3	5	1			37
						B.								
						C.								

DATE _____ MINE 59 LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 54
 COAL SEAM EAGLE NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2						A.								
						B.								
						C.								
CONTACT														
1	72 in		Sandstone with coal streaks, lag deposit, ripple marks	2	1	A.	Bedding	2	2	5	2			54
						B.	Fossils	3	2.5	3	1			
						C.	Cross Bedding	2	2	5	2			

DATE _____ MINE 59A LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 44
 COAL SEAM EAGLE NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2						A.								
						B.								
						C.								
CONTACT														
1	72 in		Sandstone, coal streaks, free fossils	2	1	A.	Bedding	2	2	5	2			54
						B.	Fossils	3	2.5	3	1			
						C.	Cross bedding	2	2	5	2			

DATE _____ MINE 60 LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 40

COAL SEAM CEDAR GROVE NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation		
												Strike		Dip
3	8 in		Shale, silty-sandy churned bedding	3	1	A.	Bedding	3	3	5	4			40
						B.								
						C.								
CONTACT														
2	18 in		Coal, top bench of Cedar Grove	3	1	A.	Bedding	3	3	5	4			40
						B.								
						C.								
CONTACT														
1	180 in		Shale, silty-sandy churned bedding fossils	3	1	A.	Bedding	3	2	5	4			40
						B.	Fossils	2	1.5	5	2			
						C.								

DATE _____ MINE 60A LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 48

COAL SEAM CEDAR GROVE NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation		
												Strike		Dip
5						A.								
						B.								
						C.								
CONTACT														
4	14 in		Sandstone, stackrock	3	1	A.	Bedding	2	3	5	3			49
						B.								
						C.								
CONTACT														
3	6 in		Shale, sandy with mica	3	1	A.	Bedding	2	3	5	3			49
						B.								
						C.								
CONTACT														
2	38 in		Sandstone, stackrock	3	1	A.	Bedding	2	3	5	3			49
						B.								
						C.								
CONTACT														
1	8 in		Shale, sandy with mica	3	1	A.	Bedding	2.5	3	5	3			44
						B.								
						C.								

DATE _____ MINE 61 LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 55
 COAL SEAM EAGLE NAME _____

UNIT						UNIT DISCONTINUITIES								Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dep			
3						A.									
						B.									
						C.									
	CONTACT														
2						A.									
						B.									
						C.									
	CONTACT														
1	84 in		Shale	3	1	A.	Bedding	2	3	4	1			55	
						B.	Slicks	4	2.25	1	1				
						C.									

DATE _____ MINE 62 LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 52
 COAL SEAM CAMPBELL CREEK NAME _____

UNIT						UNIT DISCONTINUITIES								Unit Rating
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dep		
3						A.								
						B.								
						C.								
	CONTACT													
2	192 in		Shale	2.5	1	A.	Bedding	3	3	3	1			58
						B.								
						C.								
	CONTACT													
1	48 in		Shale	3.5	1	A.	Bedding	3	3	4.5	1			42
						B.								
						C.								

DATE _____ MINE 63 LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 38

COAL SEAM CAMPBELL CREEK NAME _____

UNIT						UNIT DISCONTINUITIES								Unit Rating
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2						A.								
						B.								
						C.								
CONTACT														
1	96 in		Shale, grey	3	1	A.	Laminations	3.5	2.75	5	1			38
						B.								
						C.								

DATE _____ MINE 64 LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 63

COAL SEAM ALMA NAME _____

UNIT						UNIT DISCONTINUITIES								Unit Rating
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2						A.								
						B.								
						C.								
CONTACT														
1	72 in		Shale, fossiliferous	2	1	A.	Bedding	2	3	3	3			67
						B.								
						C.								

DATE _____ MINE _____ 65 _____ LOCATION WEST VIRGINIA _____ PAGE 1 OF 1 CMRR 53

COAL SEAM BECKLEY _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
2						A								
						B								
						C.								
1	72 in		Sandstone with carbonaceous streaks	1.5	1	A	Carbonaceous streaks	3	2.5	4	2			55
						B.	Bedding	3	3	3.5	3			
						C.								

DATE _____ MINE _____ 66 _____ LOCATION WEST VIRGINIA _____ PAGE 1 OF 1 CMRR 31

COAL SEAM LOWER KITTANNING _____ NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
5						A								
						B								
						C.								
4	18 in		Sandstone, laminated	1.5	1	A	Carbonaceous streaks	2	3	5	1			60
						B.								
						C.								
3	32 in		Shale, laminated, with sandstone stringers	3.5	1	A	Laminations	3	3	5				33
						B	Major bedding	3	3	4	4			
						C								
2	6 in		Sandstone, fine grain	1.5	1	A	Carbonaceous streaks	2	3	5	1			60
						B.								
						C								
1	42 in		Shale, laminated	3.5	1	A	Laminations	3	3	5	3			33
						B	Major bedding	3	3	4	4			
						C								

DATE _____ MINE 67 LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 96

COAL SEAM COALBURG NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2						A.								
						B.								
						C.								
CONTACT														
1	480 in		Sandstone, fine to medium grained	1.5	1	A.	Crossbed	7	2.5	1.5	4			96
						B.								
						C.								

DATE _____ MINE 67A LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 53

COAL SEAM COALBURG NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
CONTACT														
2	36 in		Sandstone, fine to medium grained	1.5	1	A.	Crossbed	1	2.5	1.5	4			96
						B.								
						C.								
CONTACT														
1	57 in		Shale, fossiliferous	3	1	A.	Laminations	3	3	5	3			40
						B.	Major bedding	1	3	2	3			
						C.								

DATE _____ MINE 68 LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 43

COAL SEAM COALBURG NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
	CONTACT													
2	18 in		Sandstone	2	1	A.	Crossbed	3.5	3	4	1			52
						B.								
						C.								
	CONTACT													
1	18 in		Dewrock	3.5	1	A.	Joints	3	3	4	2			34
						B.	Bedding	3	3	4	2			
						C.	Slicks	4	2	4	2			

DATE _____ MINE 69 LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 75

COAL SEAM STOCKTON NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
	CONTACT													
2	48 in		Shale, massive	2.5	1	A.	Bedding	1	3	2	4			88
						B.								
						C.								
	CONTACT													
1	36 in		Shale, laminated fossiliferous	3.5	1	A.	Bedding	2	3	4	3			57
						B.								
						C.								

DATE _____ MINE 72 LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 60

COAL SEAM POCAHONTAS NO. 4 NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
	CONTACT													
2						A.								
						B.								
						C.								
	CONTACT													
1	96 in		Sandstone, micaceous carbonaceous	1.5	1	A.	Bedding	3	2.5	3.5	3.5			62
						B.								
						C.								

DATE _____ MINE 73 LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 39

COAL SEAM UPPER FREEPORT NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
	CONTACT													
2	36 in		Shale, weak	2.5	2	A.	Bedding	2.5	3	5	2			44
						B.								
						C.								
	CONTACT													
1	8 in		Head coal	4	1	A.	Clst	3	3	5	1			30
						B.	Bedding	3	3	5	1			
						C.								

DATE _____ MINE 73A LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 39

COAL SEAM UPPER FREEPORT NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
5						A.								
						B.								
						C.								
		CONTACT												
4	60 in		Siltstone, with sandstone beds	2	1	A.	Bedding	1	1	1	1			62
						B.	Shears	3.5	2	2	3			
						C.								
		CONTACT												
3	23 in		Sandstone, with interbedded shale	1.5	1	A.	Bedding	2	2	5	3			56
						B.	Shear	2.5	2	3	2			
						C.								
		CONTACT												
2	36 in		Shale, with coal streaks	4	2	A.	Bedding	3	2.5	5	2			37
						B.								
						C.								
		CONTACT												
1	6 in		Head coal	4	1	A.	Clast	3	3	4	1			31
						B.	Bedding	3	3	5	1			
						C.								

DATE _____ MINE 73B LOCATION WEST VIRGINIA PAGE 1 OF 1 CMRR 66

COAL SEAM UPPER FREEPORT NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No.	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
3						A.								
						B.								
						C.								
		CONTACT												
2	78 in		Siltstone, massive conchoidal fracture	2.5	1	A.	Bedding	1.5	3	5	2			72
						B.								
						C.								
		CONTACT												
1	6 in		Head coal	4	1	A.	Clast	3	3	5	1			25
						B.	Bedding	3	3	5	2			
						C.								

DATE _____ MINE 74 LOCATION WYOMING PAGE 1 OF 1 CMRR 37

COAL SEAM HANNA NAME _____

UNIT						UNIT DISCONTINUITIES							Unit Rating	
Unit No	Unit Thickness	Strip Log	Description	Strength	Moisture Sensitivity	Disco. I.D.	Description	Cohesion	Roughness	Spacing	Persistence Lateral/Vert	Orientation Strike Dip		
5						A.								
						B.								
						C.								
CONTACT														
4	60 in		Mudstone	3.5	2	A.	No information	4	2.5	5	3			34
						B.								
						C.								
CONTACT														
3	60 in		Shale	4	2.5	A.	Laminations	3	2.5	5	2			33
						B.	Slicks	4	2	4	4			
						C.								
CONTACT														
2	36 in		Drewrock	4	2.5	A.	Laminations	4	2.5	5	4			29
						B.	Slicks	4	2	4	4			
						C.								
CONTACT														
1	24 in		Coal	4	1	A.	Clast	2	3	4.5	4			40
						B.	Bedding	3	2	4	2			
						C.	Shear	3	2	1	3			

