Gifford in association with

GEO-DESIGN

and

Forkers Ltd Civil & Ground Engineering

ROSIA MONTANA - CARNIC MASSIF

MINE MUSEUM

STABILISATION PROPOSALS AND COST ESTIMATES

MARCH 2007

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1 INTRODUCTION

Roşia Montană Gold Corporation (RMGC) propose to mine the ore reserves within the Carnic Massif by open cast methods and have prepared a comprehensive Environmental Impact Assessment for these proposals. Several questions arising during public consultation on the Assessment refer to the possibility of preserving the mine workings within the massif as a mine museum. The mine workings are very extensive and include Recent, Modern (largely medieval) and Roman workings. A variety of mining methods are represented, with the overall underground development extending to an estimated 52km of workings, developed in over 25 levels.

Underground openings developed for mining are not necessarily designed for long term stability, with the size of the openings being maximized for efficiency of working. Whilst the Roman workings generally comprised smaller openings, these have, to a large extent, been reworked and combined during Modern and Recent times into larger openings. The workings are thus in a variety of stability states, ranging from relatively stable to essentially collapsed, with many in a dangerous state quite unsuitable for public access without an extensive programme of stabilisation.

The extent of Recent workings is well known and recorded on detailed scaled mine plans. The Roman workings have been investigated over the past seven years by a team of archeologists led by Dr Beatrice Cauuet, who in the period 1999-2006 performed a vast program of mining archeological investigations. This large research was carried out within The “Alburnus Maior National Research Program” under the care of National History Museum of Romania, Project Manager Dr Paul Damian.

The long history of mining has left a legacy at the surface in the form of spoil heaps that extend across the majority of the surface of the Carnic Massif. The spoil heaps represent a significant hazard to the construction of access roads across the massif to the mine entry and exit points.

Geo-Design (a specialist rock engineering consultancy) in association with Gifford have been commissioned by Roşia Montană Gold Corporation (RMGC) to undertake an assessment of the extensive existing underground mine workings within the Carnic Massif. The aim of the assessment is to provide an opinion on the feasibility of preserving the mine workings and to develop a basis for the estimation of the cost of turning the mine workings into a Mine Museum.

The findings of the assessment in terms of the extent of measures required to develop a museum are presented as Tables, Figures and limited text. Forkers Ltd, a UK based drilling and mining company that has specialised in the stabilisation of mine workings, have prepared cost estimates based on the scope of works defined in this report. Their estimates are summarised in Section 7 of the report.

The extent of the workings presents many alternatives for the format of guided tour. A tour comprising some 25 stops and taking an estimated three hours to complete has been developed with assistance from Dr. Calin Tamas (Babes-Bolyai University, Cluj-Napoca), who worked alongside the archeological teams and therefore has a detailed knowledge of the extent of the workings.

The tour is illustrated in schematic form in Figure 1.1 in relation to each of the mining areas to be visited. The schematic plan has been overlaid on an aerial photograph in Figure 1.2 to assist with orientation. A summary of the work required is included as Appendix A, which cross refers to further Tables in the Report for details. Plates taken by Geo-Design during an inspection of the mine in February 2007 are included in this report.

The Tour is intended to include a sample of the full variety of methods of working that have been used within the Carnic whilst being limited to those areas that can be reasonably preserved. The Tour therefore avoids areas of extensive collapse. However, areas within the tour are still very extensive, highly complex in terms of geometry and stability condition. They are arranged in an

intricate, three dimensional network of openings and adits and many areas on the tour could be adversely affected by instability in adjacent openings (above, alongside or below) that are not included within the tour. The sketches available from the archeological team represent exquisite pieces of work, but cannot fully convey the three dimensional complexity of the openings and thus estimates of stability condition and stabilisation requirements can only be hesitantly judged at this time.

The tour outlined in this report is approximately 4.1km long passing through workings developed with a variety of methods and over several time periods. In addition many of the workings adjacent to the 4.1km tour route would require backfilling or stabilising.

It should be appreciated that there is no precedent for a mine museum on this scale or complexity. Despite the efforts expended to date and the availability of mine records from the archeological team, all quantity and programme estimates are subject to significant but unquantifiable uncertainty. A cost risk analysis has not been undertaken but it is clear however that a significant contingency sum will need to be applied to the cost and programme estimates. To upgrade this document to provide more confidence to the assessment and reduce uncertainty would require many man months of detailed investigation, inspection and survey. Even then, uncertainty and associated cost risks would remain through the construction period.

The scope of work required is extensive. In order to maintain the safety of the public in a relatively low risk environment, as well as extensive stabilisation works to areas of the mine directly within the Tour, extensive stabilisation via backfilling of adjacent unstable openings will be required. Estimates of the extent of many of the adjacent openings are not fully known. New access adits must be created to provide emergency egress and exit, new shafts must be constructed with lifts to link the various levels and extensive stabilisation of the areas within the tour are required. Additional facilities that are required for the creation of a mine museum include access roads and a visitors centre. Trained emergency personnel would need to be on standby in case of an incident.

The costs will be prepared under the following categories :

- Associated Facilities
- Access Roads - Car Parks
- Slope Stabilisation and Landscaping
- Portals
- Shafts
- Intervening Access Adits
- Modern Workings
- Ancient Workings
- Annual Operating Costs

The surface conditions also present a challenging engineering environment. It includes steep natural slopes, extensive areas of tipped mine waste often residing at very steep, unstable angles, areas of

mine collapse causing subsidence and collapsed ground. These areas need to be traversed by newly constructed roads to provide access to and between the mine museum areas.

The cost of some of the elements of the mine museum, such as intervening adits and shafts will depend in part on the number of people anticipated to be underground at any one time and the number expected to be within any single tour. The most significant impact is on the costing for the several shafts and associated lifts. The sizing and associated costing should assume that there will be a maximum of 15 people in any area of the mine at any one time.

2 METHODS OF MINING

2.1 Methods of Excavation

A number of different mining methods have been used at Carnic to exploit the ore reserves. These include the following :

- Hand tools
- Fire setting
- Drill and blast
- Caving

Hand tools were widely applied by the Romans for the excavation of their adits. The adits were formed with a constant trapezoidal geometry, which served to limit the crown span whilst providing increased width. The profile was formed irrespective of the rockmass structure and could not have been achieved using modern drill and blast methods.

In areas of very good rock mass conditions and high rock strength, excavation by hand tools would have been extremely slow and possibly uneconomic. In these areas, the Romans applied an alternative method comprising the lighting of fires at the heads of adits that resulted in rapid heating and cooling of the rock mass causing exfoliation of the rock surface (similar to peeling of an onion layer). Underground fires can be controlled by ventilation and can as result be very intense. This method forms characteristic rounded excavation profiles.

Drill and blast comprised the drilling of a pre-defined pattern of drillholes which are charged with explosives and detonated. The charges are timed via the use of delays such that they are detonated as a sequence of small controlled explosions in order to limit the adverse effects of blasting.

2.2 Mine Geometry

These methods of excavation have been applied in a number of ways depending on the arrangement of the ore and the techniques available at the time of excavation. Several forms of mine openings are present, which include :

- Adits
- Horizontal room and pillar
- Stopes
- Corandas

These are briefly described below.

2.2.1 Adits

The ore is often most concentrated in narrow high grade zones that can be exploited using relatively small diameter openings (Plate 19). Where there are several closely spaced veins, the adits may be in close proximity, concentrated within a small area. In these areas were the adits are closely spaced, they form a network with either horizontal or vertical intervening pillars, depending on the layout of the adits (Plate 27).

2.2.2 Room and Pillar

Room and pillar methods were commonly applied in the 17th to 19th centuries worldwide. The method comprised working a typically horizontal heading of constant height, leaving pillars of rock in place that support the crown of the excavation as the material around is removed (Plates 5,6 and 7). Where the ore is extensively developed several levels of workings can be developed one above the other. A key issue, depending on the vertical separation of the levels, can be the positioning of the pillars to ensure that they are inline one above the other.

2.2.3 Stopes

Stopes are vertical developments formed to exploit so called stockwork (closely spaced veining) or breccia dykes. In several areas of the mine, these were originally worked as a series of stacked horizontal adits which have had their intervening pillars subsequently removed. (Plates 12, 16, 17 and 21)

2.2.4 Corandas

Corandas are large steeply inclined voids that are worked either from the top or from the base upwards. They are entirely unsupported and are developed without any pillars. Such large voids are typically developed in areas of good rock mass conditions, however the high side walls are typically vertical and vulnerable to discontinuity controlled block failures.

3 DESCRIPTION OF THE MINE WORKINGS

Mining has taken place in the Rosia Montana area since during the Roman times. Three main periods of mining activity have been defined :

- Recent mining works (20th Century)
- Modern mining works (17th to early 20th Century)
- Ancient mining works

3.1 Recent Mine Workings

The Recent Mining activity, which is of the order of 27.7 km, is represented by mining works carried out during the 20th Century, predominantly in the period after nationalization (1948). The mining works of this type are easily recognised through their arrangement as rectangular galleries. The galleries had several functions, including access, transport, exploration and mining. These works often intersect the older works, allowing access to most of the older mining works.

The recent mining works are present as galleries with uneven profile, typically rectangular, excavated using drill and blast methods, and are typically straight. The mining activity continued in the vein structures through the development of galleries, and within the breccia bodies and stockwork in the form of large vertical or steeply inclined chambers without pillars (corandas), and after 1961 in the form of very extensive room and pillar developments (Plate 7).

The support within the galleries depended on the geological conditions and comprised concrete, or with concrete bricks, metallic frames, or timber props. In the more favourable mining conditions, the works were not supported. Where timber supports were used, the condition of the galleries is typically in a state of collapse, resulting in currently inaccessible sectors of workings.

The areas that are highly mineralised and extensive in area were worked by multi-level room and pillar. Two such areas were mined, the Napoleon sector comprising 17 mining levels and the Corhuri sector comprises 24 mining levels. These mining levels are connected through rising shafts (sometimes intact). All 24 levels open out into a very large Coranda (Coranda Corhuri) that is developed over the full height of the workings in this area.

3.2 Modern Mine Workings

The modern mining works within the Cârnic Massif total a length of 20 km of adits and associated larger openings.

These are largely represented by vestiges of mining activity carried out after the introduction of drill and blast techniques. Pošepny's Geological Map dated 1868 records about 40 modern galleries and by the time of the publication of Ghițulescu and Socolescu's Map in 1941 about 70 modern galleries can be recognised.

The galleries are in general unsupported, of variable geometry according to the overbreak that occurred, usually having the height of a man and a modest width (typically 1m). Some galleries are more rectilinear, sometimes being equipped with wooden rails. These mining works were sometimes, when required, supported with timber props, and as a result, many of them are now inaccessible due to the falling of the supports and the onset of collapse. The veins were mined

through faces (usually inclined - consistent with the orientation of the ore bodies), while the exploitation of the breccias bodies and stockwork type structures resulted in the creation of medium sized “corandas” that consist of larger vertical openings with no intervening pillars.

3.3 Ancient Mine Workings

Carnic 1

The mining works from Carnic 1 network are characterised by stepped and inclined stopes and adits. These are developed with a total level difference of 50m (923-973mOD). The mining works consist of eight inclined to very inclined stopes, five room and pillar areas and six inclined shafts. Three levels of mining works are defined (Upper, Middle and Lower), each level being further sub-divided into three or four floors with a sometimes narrow thickness of rock between. (Plates 11 and 12).

Carnic 2

Carnic 2 network is situated nearer to the surface than Carnic 1. The two networks are connected by their lowermost floors. Carnic 2 network contains three main levels (Upper, Middle and Lower), the middle level being divided into two levels consisting of inclined exploration adits. Within the upper level, there is a long (70m) inclined exploration adit (G31), with 125 steps descending a total distance of 30m and equipped with over 20 notches for lamps in the upper parts of the walls. Two room and pillar levels and two Corandas (large unsupported stope) are also present within the Carnic 2 network. One of these Corandas is very large and inclined and has been largely re-worked by modern mining techniques removing the majority of supporting pillars. Within the re-worked areas of Carnic 2, evidence of the ancient workings can be seen in the form of remaining adits and some stopes. There is also a shaft that connects the Middle and Lower Carnic 2 levels.

Carnic 3

Carnic 3 is an ancient network linked to surface by a 50m long inclined adit (G2), this adit is in a state of collapse from the network up to the surface. The mine workings are developed horizontally from this adit in all directions. The network contains seven room and pillar mining chambers. The perimeter of the chambers is marked by trapezoidal adits believed to have exploited localised mineralised veins. The modern and recent mining of the room and pillar chambers has removed the majority of the supporting pillars creating an area of high instability; preservation of these areas requires an extensive support scheme. Within the Carnic 3 network there are also two long exploration adits leading into stopes, shafts and further exploration adits (Plate 14).

Carnic 4

Only the lower level of this mining network, consisting of adits, one stope and one shaft, is accessible the upper and middle levels are in a state of advanced collapse and can only be accessed by trained personnel.

Carnic 5

The ancient Carnic 5 mining network is also in a very unstable condition and consists of a stope intersected by mining networks to the north and south. The ancient works are in two levels that contain one adit, one vertical stope and one access adit (the lower level), while the upper level is made up of several exploration adits and linked to the lower level via a vertical shaft.

Carnic 6

The Carnic 6 network comprises a reworked (modern) lower level and an ancient upper level. The lower level contains a wooden rail. The upper level was uncovered during the archaeological exploration and has been defined as a drainage adit. The two levels, although cut across by a recent stope, are not in direct connection. The area is affected by a constant and abundant water flow.

Carnic 7

The Carnic 7 network is characterised by a series of ancient stopes developed via the use of fire setting techniques (CH14 and CH9). The network is located near to the surface causing stability problems to the dome stopes. These workings are very high and some have collapsed to surface forming crown holes. The stopes situated within high grade rock have largely been re-worked extensively by modern and recent mining methods.

Carnic 8

The Carnic 8 network is situated at a shallower depth very close to the surface with consequent instability problems. Access is very difficult and dangerous.

Carnic 9

The Carnic 9 network consists of a vast group of mining workings (75% being recent workings) spread on four levels, these workings were primarily developed using modern drill and blast techniques. The majority of the ancient workings within Carnic 9 have been reworked and their stability reduced by the modern workings. The Carnic 9 network is connected to the surface by an inclined adit. Lower in the network, there is an area made up of small, narrow worksites dug out with tools. These workings appear to have been opened up sometime between the end of the Roman era and the 17th Century, prior to the time when explosives were beginning to be used in the mining industry. The third area within the Carnic 9 network consists of room and pillar mining workings and some ancient workings.

Carnic 10

Mining workings located in the Eastern part of the Carnic 10 network have been extensively re-worked by modern and recent techniques resulting in large areas of collapse and instability. The areas of interest are those located in the centre of the network and the workings on the Western flank. Carnic 10 is characterised by groups of steeply dipping workings where mineralised veins running parallel to one another have been exploited. The workings comprise a series of trapezoidal adits located roughly parallel to one another, following inclined mineralised structures such as veins (horizontal and vertical) and breccia ore bodies (breccia dykes). Subsequent mining has resulted in the removal of much of the intervening pillars leaving large unsupported spans. There is also an isolated lower level consisting of four small exploration adits mined laterally. Ancient workings located in the lower parts of the Eastern flank have been significantly altered and backfilled by modern mining.

Carnic 11 and 12

The Carnic 11 and Carnic 12 networks consist of vertical mine workings exploiting parallel vein structures.

Carnic 13

The most elaborate workings within the Carnic 13 network consist of an inclined research adit worked on steps (approximately 17m long) from a collapsed stope. This stope is thought to have been reinforced by a wooden structure; this has been confirmed by the discovery of traces of the propping structure preserved in the backfill sediments. The network is affected by constant flooding and inflow of fine sediment from weathered material above.

Carnic 14

A series of small ancient mine workings have been found within Carnic 14 network, these were covered by modern waste dumps.

Carnic 15

Carnic 15 network consists of ancient mine workings developed using fire setting and hand tools. The network comprises eight levels all accessible directly from surface. There are numerous areas of mine workings that cannot be directly connected to one another. This network has been extensively reworked by modern and recent mining and is a poor state of stability.

Carnic 16

Carnic 16 network consists of ancient vertical workings that intersect with the crown of a modern Coranda.

Carnic 17

Carnic 17 network is made up of two ancient mining networks consisting of a downward inclined adit and a gallery intersecting an inclined stope. These workings can be seen within a modern Coranda.

Carnic 18

Carnic 18 network consists of a short gallery and a steep descending inclined adit intersected by a recent gallery.

Carnic 19

Carnic 19 network is made up of three sectors of ancient galleries that have been partially reworked by modern mining and now delineate a large Coranda in a poor stability condition.

Carnic 20

The Carnic 20 network comprises fragments of ancient galleries and reworked pillars in an area of poor rock mass conditions.

Carnic 21

Carnic network consists of mining workings that have been excavated by fire resulting in rounded walls and ceilings. The network is linked directly with the surface.

Carnic 22

Carnic 22 network is parallel to Carnic 21 network and consists of mine workings using fire setting techniques. This network has been extensively reworked and backfilled.

Carnic 23

The Carnic 23 network consists of a vertical stope and a silted up inclined adit that have been extensively reworked by modern mining.

Carnic 24

The Carnic 24 network is made up of three sectors of ancient mine workings (two inclined adits and an inclined stope). These mining workings have been extensively reworked and destabilised by modern mining.

Carnic 25

The Carnic 25 network consists of collapsed ancient mine workings located at 15m below surface.

4 GEOLOGICAL OVERVIEW

4.1 Overview

The Carnic Massif is an intrusive, volcanic, igneous body that has been subjected to hydrothermal alteration and structural deformation. The Dacite rock mass is present as an igneous body that intruded into Cretaceous sediments and acted as a volcanic plug to the Andesite Stratavolcano that was present in the area at that time. The Dacite body was subsequently subjected to structural stress resulting in faulting and fracturing of the rock mass. Hydrothermal fluids associated with the magma body entered the Dacite along the pre-existing structure resulting in mineralisation and alteration of the rock mass. The mineralisation formed the ore that has been mined. The alteration has had a major impact on the strength of the Dacite, which is highly variable. The following Lithologies are present within the Carnic Massif.

4.2 Lithology

4.2.1 Andesite

Andesite is a grey to black, volcanic, igneous rock made up of plagioclase feldspar, pyroxene minerals and hornblende. Andesite is associated with large stratavolcanoes and as thick lava flows. At the Carnic Massive, the Andesite has been almost totally eroded and is present only as isolated boulders such as the one seen at Piatra Despicată.

4.2.2 Dacite

Light grey to dark grey, volcanic, igneous rock made up of plagioclase feldspar, pyroxene and amphibole. Dacite is a viscous lava commonly associated with explosive volcanoes such as Mount St Helens and Plinian-style eruptions. Dacite is the host rock to the ore and all the mine openings are formed with Dacite.

The Dacite is vulnerable to both alteration and weathering, both have a significant control over the rock mass conditions in the mined area.

4.2.3 Structure

The Carnic is cross cut by large scale, regional faulting and associated smaller scale, localised faulting. Some these fault structures were subsequently mineralised by hydrothermal fluids associated with the main magma chamber. The majority of the ancient mine workings were located along a large mineralised fault breccia that strikes north south and is steeply dipping, typically at 80 degrees. Mine networks surrounding the fault breccia also exploited subhorizontal mineralised veins and breccia dykes that branch from the main structure.

In addition to large scale structure, small scale discontinuity systems are also present within the Dacite. In general, discontinuities (joints) are poorly developed within the Dacite which can often be described as massive with few visible joints. The dominant set strikes north south parallel to the main breccia ore body dipping also at approximately 80 degrees. Close to the main ore bodies, the joint set is closely spaced and thoroughgoing, typically being persistent over lengths of greater than 10m. The joints become less persistent and more widely spaced further away from the ore bodies and associated structures. A secondary, steeply dipping set striking perpendicular to the main set is also present but generally poorly developed and incipient.

Typically, a subhorizontal set is very poorly developed, usually incipient with small persistence. However, locally, undulating but persistent clay infilled horizontal structures are present and create potentially very adverse stability conditions. These structures typically occur in a consistent position in relation to the higher grade ores. Where present in the crown zone, the structures have a significant controlling influence.

4.3 Alteration

Alteration is a process where minerals within a rock material are chemically changed, often having a significant effect on the rock strength. Hydrothermal alteration is associated with igneous activity and is the main type of alteration within the Dacite.

There are two main types of hydrothermal alteration seen within the Carnic Massif comprising silicification and argillic alteration, both considerably affecting the strength of the Dacite host rock.

Silicification is the process of introducing silica into the matrix of the rock, in this case via the enrichment of the host rock by the silica rich hydrothermal fluids moving through it. The process acts as a re-cementation process, significantly increasing the strength of the rock in a relatively narrow area within and adjacent to the mineralised faults, joints and fractures. The extent of the silicification varies but is typically only a few metres and has a graded contact with the unaltered Dacite.

The second principle form of hydrothermal alteration seen within the Carnic Massif is argillic alteration, which is a process of converting one of the Dacite minerals (plagioclase feldspars) within the Dacite into clay minerals. The feldspars can form up to 30% of the rock material hence argillic alteration produces a significantly weathered rock material

4.4 Weathering

Weathering processes that occur in association with near surface, sub-aerial systems also result in the decomposition of the rock. The degree of decomposition varies with depth, eventually producing soil-like materials near surface with the degree of decomposition decreasing with depth. The degree of decomposition also varies with the condition of the original rock mass. Weak and permeable rock masses that have already been partially decomposed by an alteration process will be vulnerable and weathering profiles can be expected to extend to depth (tens of metres) whereas the silicified rock materials are very resistant to sub-aerial and a much reduced profile can be expected in these areas.

4.5 Engineering Geological Model - Implications for Mine Stability

The key attributes of the Dacite rock mass within the Carnic Massif are as follows :

- Narrow zones of competent silicified rock mass adjacent to and within zones of mineralisation (ore that was mined)
- Weak, partially altered (decomposed) rock mass in all areas away from the mineralisation
- Throughgoing, subvertical structure parallel to the steeply inclined, mineralised zones
- Localised, clay infilled, subhorizontal structures
- General reduction in rock mass quality with reduced depth from surface except in zones of mineralisation

This simplified model of the engineering geological conditions is relatively well defined in zones of mineralisation associated with the Ancient Workings. These are concentrated along a single mineralised fault breccia zone with localised, subhorizontal and inclined branching veins. In these areas, mine openings that have remained within the zone of silicification associated with the ore body and still have a 'cover' of silicified rock in the sidewalls or crown are in a relatively stable condition. However, those that have been mined further to the edge of the zone of silicification or actually extend into the argillically altered (partially decomposed) rock are in a relatively unstable condition and have already collapsed or would require substantial support to preserve the opening in the long term. The conditions are made worse where mine workings are located closer to ground level where the rock mass conditions have been further adversely affected by weathering.

Structure also has a significant controlling influence on stability of the mine openings. The subvertical mine openings (stopes and corandas) that have mined the main fault breccia have high sidewalls that trend parallel to the main joint set. The openings are often defined by the exposed surface of joints and further thoroughgoing structure is present behind the side walls, defining slabs of rock trending parallel to the openings. These high side walls are therefore vulnerable to topple failure of the slabs of rock and, for the larger openings, buckling failure of the slabs. The stability of the horizontal and inclined openings is not controlled in the same way by the rock mass structure.

For the subvertical stopes and corandas, a series of rock mass classes can therefore be defined according to the degree of silicification and the development of thoroughgoing parallel structure. These classes refer to the conditions in the high side walls which are the primary areas requiring support in the stopes and corandas, as follows :

ROCK MASS CLASS	KEY FEATURES
SW 1	Closely spaced, throughgoing, subvertical structure Highly silicified, very strong rock
SW 2	Closely spaced, throughgoing, subvertical structure Slightly silicified, moderately strong rock
SW 3	Widely spaced, throughgoing, subvertical structure Unsilicified, altered rock
SW 4	Poorly developed, subhorizontal and subvertical structure Unsilicified, altered and highly weathered rock

For the inclined and subhorizontal openings, a different set of rock mass classes can be defined that are controlled by the degree of silicification and the presence of clay infilled, subhorizontal structure.

These rock mass classes refer to the condition in the crown, which is the primary area if the mine requiring support in the subhorizontal mine areas. The classes are as follows :

ROCK MASS CLASS	KEY FEATURES
CR 1	Poorly developed, subhorizontal structure Highly silicified, very strong rock
CR 2	Poorly developed, subhorizontal structure Slightly silicified, moderately strong rock
CR3	Well developed, thoroughgoing, subhorizontal clay in filled discontinuities. Slightly silicified, moderately strong rock
CR 4	Poorly developed, subhorizontal structure Unsilicified, altered rock
CR 5	Poorly developed, subhorizontal structure Unsilicified, altered and highly weathered rock

4.6 Rock Mass Assessment - Q

The Q system of rock mass assessment provides a means of characterising a rock mass according to the main attributes to derive a single value representative of the overall rock mass condition. Via empirically established relations, it is possible to derive the likely range of support requirements by relating the derived Q value to the span of the opening and the intended use. The Q system is a useful method to derive a preliminary assessment of support requirements.

A Q assessment has therefore been undertaken for each of the defined rock mass classes that are based on the key controlling rock mass attributes, as observed by inspection of the mine openings

and, in the context of the regional geology, has also been undertaken as a part of this study and is presented as Tables 4.1 and 4.2 for the crown zones and 4.3 and 4.4 for the side walls.

The upper and lower bound values are intended to provide an assessment of the range of conditions to be expected within each of the Rock Mass Classes.

Q values are calculated according to the system detailed in Grimstad & Barton (1993).

$$Q = \frac{RQD}{J_n} \times \frac{J_r}{J_a} \times \frac{J_w}{SRF}$$

A brief explanation of the derivation of the constituent parameters is provided below and a summary of the input parameters and derived Q values are listed in the Tables.

Rock Quality Designation (RQD)

RQD is an indirect measure of the rock mass quality (it is arbitrarily defined as the percentage of a core that measures greater than 100mm in length). Despite the arbitrary origins, it has become a widely measured attribute.

A brief inspection of photographs of core from boreholes that were taken from surface and extend close to and through the ancient mine workings was undertaken. A characteristic of the core was the generally very low RQD values for the majority of the core that passed through the partially altered rock mass. Higher values can be anticipated to be associated with the silicified zones, and this has been allowed for.

Joint Number (Jn)

The joint number increases with the number of joint sets that are present and has an influence on the stability. The Joint Number is therefore low, indicative of typically a single joint set being influential on stability. In the more altered rock masses, an allowance for so-called random sets has been allowed for which are present but largely incipient in the better rock mass conditions.

Joint Roughness (Jr) and Joint Alteration (Ja)

Joint Roughness and Joint Alteration have been assessed according to the nature of the controlling discontinuity set and based on preliminary observations made underground.

Joint Water Reduction Factor (Jw)

The influence of groundwater is more pronounced in the more permeable, altered rock masses and this has been reflected in the assessment made.

Stress Reduction Factor

The in situ stress conditions can have a significant control on stability as the strength of all rock masses that are influenced by discontinuities is stress dependent. In general, the mine is in an area of low in situ stress with no signs of stress induced failure within the mine areas that were visited. Of more significance will be the low stress environments that are present for those areas of the mine that are under very shallow cover, with adjacent areas of collapse.

5 PROPOSED MINE TOUR

The mine workings are extensive and many are in a dangerous state of collapse. A tour has therefore been defined that includes examples of all the mine methods and ages of application. The tour is summarised as follows :

Tour Stage	Description	Age of workings
1	Access from surface through gallery at +958 level	Recent workings (Plates 1 to 10)
2	Travel on the electric train to "Coranda Corhuri"	
3	Coranda Corhuri	
4	Corhuri shaft	
5	Corhuri ,room and pillar	
6	Return trip from Coranda Corhuri to Carnic 1 mining network	
7	Carnic 1 ancient network	Roman workings (with local ancient reworking) (Plates11 to 20)
8	Trip from Carnic 1 network to Carnic 3 network	
9	Carnic 3 ancient network	
10	Carnic 2 ancient network	
11	+932 working level	
12	Carnic 5 ancient network	
13	travel within +932 working level from Carnic 5 network to Carnic 6 network	
14	Carnic 6 network	
15	Travelfrom +932 to +960 working level (via shaft)	
16	Travel within +960 working level, from shaft to Carnic 13 ancient network	
17	Carnic 13 mining network	
18	Travel from Carnic 13 to Piatra Corbului sector (Carnic 21, Carnic 22)	Roman workings - worked using fire setting techniques (Plates 21 & 22)
19	Carnic 21 and Carnic 22 ancient networks	
20	Exit from Carnic 21 and Carnic 22 (Piatra Corbului)	
21	Travel at surface to entrance of Carnic 9 ancient network	Roman workings (Plates 23 to 27)
22	Carnic 9 ancient network	
23	Travel from Carnic 9 mining network to Carnic 10 mining network	
24	Carnic 10 ancient network	
25	exit at the surface, conclusion of underground tour.	

The trip would take approximately 2.5 to 3.0 hours to complete.

Figures 5.1 and 5.2 are reduced versions of the Recent mine layouts and assist with illustrating the location of Stages 1 to 6 in relation to the later stages within the Roman workings.

6 OUTLINE OF REQUIRED SCOPE OF WORKS

6.1 Associated Facilities

A number of facilities will be required to serve the public these include the following:

- Visitors Centre
- Changing facilities
- Toilets
- Power Supply and Lighting
- Water supply

The size of the mine museum, the capital cost of the stabilisation and provisioning works, together with the extent and variety of workings, warrant a comprehensive visitors centre that will provide welfare, information, displays and limited conference - discussion areas and in addition the ticketing facilities and shop. It is likely that the centre would be located in the main square in Rosia.

It is intended that much of the intervening adits between the areas of working will be concrete lined and therefore will provide a relatively clean environment. The remaining areas will be provided with walkways. However, despite these provisions, the environment will be dirty and overalls will be required. Changing facilities are therefore needed at the commencement of the tour.

A number of welfare facilities will be required both at surface and underground. It has been assumed that 2 facilities will be provided at surface, on the Carnic Massive and 2 further facilities underground.

Power supply and lighting will be required along the full length of the tour.

Water supply will be required to the visitor's centre and welfare facilities. There is currently no reliable source of water within the town and provision has been made for 2km of pipework from one of the existing lakes together with a small processing plant.

6.2 Access Roads - Car Parks

Access is required from the visitors centre to the start of the tour (entrance to 958 level). It assumed that access will need to be to the standard (in terms of safety and gradient) of a minor public road. Other access roads are required from each of the portals and shafts, some of which will require access for emergency services. The layout of the access roads is provided on Figure 6.1 and a summary of the roads is provided on Table 6.1.

6.3 Slope Stabilisation and Landscaping

Over 7km of access road is required to provide access to each of the entrance and exit points on the tour. These roads traverse a combination of steep natural side slopes and oversteep waste tips that cover much of Carnic. The tips are largely end tipped from adits down the steep natural topography and are therefore in an unstable condition. Significant engineering will be required, comprising

largely reprofiling and removal of the tipped material. The areas requiring reprofiling are illustrated on Figure 6.2 and an estimate of the volume of material to be removed is summarised on Table 6.2. The material will be taken to Cetate Open Pit to assist with restoring this area and assist with stabilisation of the north eastern corner of the pit where an access road passes close to the crest of the cut slope.

6.4 Portals

A list of portals from adits and shafts is provided on Table 6.3 and their locations are shown on Figures 1.1 and 1.2. All the adits and shafts that come to surface will be concrete lined and therefore no major works are required for the small portals.

Two of the portals, Portal 2 and Portal 9, will be newly formed from the top of the rising shafts, Shaft 2 and Shaft 4 respectively.

Some of the portals will however require timber entrances to illustrate the original construction and support methods and some landscaping will be required, possibly with localised slope stabilisation. A provisional sum should therefore be allowed for each portal.

6.5 Shafts

Due to the large vertical separation between some of the mine areas and the need to provide alternative means of access to other areas, several shafts are required. Due to the heights involved, these will need to be fitted with high capacity lifts capable of taking 15 people at any one time. The location of the shafts is shown on Figure 1.1 and 1.2. The shafts are summarised in Table 6.4.

6.5.1 New Shafts

Shaft 1

Shaft 1 is located within the Carnic 6 mine network, 932mOD, leading up to the Carnic 13 network, 960mOD (see attached plan). Shaft 1 is the planned access route between the two networks; no other route is possible due to the poor condition of the neighbouring workings.

Shaft 2

Shaft 2 is located within the Carnic 21 & 22 mine networks at 960mOD (see attached plan). The shaft will surface at ground level, 1000mOD, and will act as an emergency exit for this section of the mine tour.

Shaft 4

Shaft 4 will be a new shaft progressed from Carnic 10 (978mOD) to surface (999mOD). The shaft will act as an emergency exit from Carnic 9 and Carnic 10.

6.5.2 Existing Shafts

Shaft 3

Shaft 3 is located adjacent to the Recent Coranda Corhuri and room and pillar mine workings at 958mOD (Figure 1.1). The shaft will provide emergency access down to 853mOD where there is an adit leading out to surface. The existing shaft at this location has been partially backfilled and will need to be emptied and widened to accommodate a lift.

6.6 Intervening Access Adits and Adjacent Workings

6.6.1 Adits

Approximately 3.0km of adits are required to link all the mine areas on the tour. It is proposed that all these adits will be concrete lined, with flat concrete inverts to provide a completely safe and low (as far as possible) risk environment. One will be fitted with an electric train to reduce walking distance and travel time and add further interest to the tour.

A variety of works associated with these are required, that include :

- Relining existing adits
- Widening and lining of existing adits
- Excavation and lining of new adits

Some of the adits are to be formed between areas of the Roman mine workings through particularly collapsed and unstable ground. Pre-grouting and temporary support of these areas may be required.

Each of the adits and requirements are listed on Tables 6.5.1 to 6.5.4.

6.6.2 Adjacent Workings

A provision in the cost estimate needs to be made for the backfilling of workings adjacent to the tour to provide an economical long term stabilisation solution. These include recent adits, but also several of the adjacent Roman workings that are in a state of collapse.

The current estimate of the backfilling requirements are listed on Table 6.6.

6.7 Modern Workings

The tour includes a visit to the modern workings, which comprise room and pillar workings and a large vertical stope (large rectangular open shaft). In outline the works comprise as follows :

- Stabilisation of areas not included in the tour by backfilling
- Temporary Stabilisation via backfilling to provide support and temporary access
- Permanent stabilisation of areas included within the tour

6.7.1 Stabilisation - Backfilling

6.7.1.1 Coranda Corhuri

Coranda Corhuri is deemed too unstable to allow public access in its current condition. It is planned to temporarily backfill the Coranda to provide support to the sidewalls and access for stabilisation. The crown will then be stabilised, and the backfill then incrementally removed systematically allowing support measures to be applied to the Coranda side walls.

The lower 70% of the coranda is already in filled with archaeological digging waste and collapsed material from the coranda side walls. The upper 30% is open but unstable and requires stabilisation, however access is impossible without first temporarily backfilling the remaining 30%.

The work required is outlined below.

Volume of Coranda

Cross Sectional Area = height x width of upper + height x width of lower
= (130 x 40) + (50 x 45)
= 7450m^2

Average thickness of Coranda = 35m

Volume of the Coranda = 7450 x 35
= 260750m^3

Grouting of Lower 70%

The backfill material within the bottom 70% of the Coranda is likely to have a void ratio of approximately 40%, consolidation grouting of these voids is therefore necessary to stabilise this section of the mine. Calculations for the volume of grout required are provided below;

- Volume of backfilled Coranda:

  Volume = 260750m^3 x 0.70
  Volume = 182525m^3

- Volume of voids within backfill material:

  Volume of voids = 182525m^3 x 0.4
  Volume of grout = 73010m^3

Temporary Backfilling of Upper 30%

The remaining 30% of the Coranda requires temporary backfilling to provide access and temporary stability. The volume of backfill required is calculated below;

- Volume of backfill:

  Volume = 260750m^3 x 0.30
  Volume of temporary backfill = 78225m^3

Permanent Support to Upper 30%

The permanent support has been assumed to comprise 10m long rock bolts on a 2.5m by 2.5m grid.

Surface area of crown	= 1400m^2
Surface area of side walls	= 6300m^2
No of bolts - side walls	= 1260
No of bolts - crown	= 280
Total number of bolts	= 1540

Temporary Access to Coranda Corhuri to facilitate remedial works

Access to the Coranda Corhuri can be gained through existing adits extending from the south west on 4 levels and through a shaft in the crown. The lengths of horizontal adits and vertical shaft that connect to surface are presented in Table 6.7, together with their stabilisation requirements.

6.7.1.2 Room and Pillar Workings

The room and pillar workings are located adjacent to the Coranda Corhuri and consist of 23 levels ranging in widths from 20m up to 140m. The room and pillar section of the mine located on the 958mOD level will be retained for public access as apart of the mine tour. The remaining 22 levels, 9 above and 13 below will be backfilled. The room and pillar levels are linked by a series of shafts and these will also require backfilling, but some will be required during the backfilling as they form the only access to some of the levels.

Calculations of the volume of backfill required are presented in the Tables 6.8.1, 6.8.2.

Bulk heads will need to be constructed along the full side of the room and pillars were they open out into the Coranda. The approximate dimensions surfaces areas of the bulkheads are shown below :

Dimensions of room: Length = 4.60m, Height = 2.25m
Surface area of bulkhead for 1 room = 10.35m^2
Total surface area of bulkheads (all 23 levels) = 1905m^2

There is a second area of room and pillar mine workings within the southwest of the Carnic Massif. These workings consist of 10 levels from 958mOD to 1018mOD. Calculations for the volume of backfill required are presented in Table 6.9.

The levels of the room and pillar workings are connected by a series of shafts. Six of the levels are connected to surface via existing adits and the remaining levels are accessed via one to two shafts linking each level. The access to each level is presented in Table 6.10. The condition of the connecting shafts and adits varies greatly and it has been assumed that all shafts and adits will require widening and stabilising before use. Most of the shafts are either unsupported or have closely spaced, wooden props and are in a dangerous condition.

6.8 Ancient Workings

6.8.1 Stabilisation

The ancient workings comprise the most complex area of the mine tour and are the most challenging in terms of an assessment of this kind. The strategy adopted to arrive at a preliminary support solution has been outlined in Section 4 of this report. In summary, this has comprised identification of the key attributes of the rock mass that control stability and using these to define rock mass classes. The rock mass classes have been subsequently characterised to derive a 'Q' Value, as an index of the rock mass quality. The mine workings have been subdivided in to areas, (and sub areas) usually according to elevation. Each area and sub area has been assigned a rock mass class and this, together with the typical dimensions, has been used to derive, via empirical methods, a support layout.

A schematic representation of each of the ancient networks is included as Figure 6.3. The networks are illustrated in relation to the depth from surface and associated weathering profiles, but also the extent of silicification around the opening. Details of the rock mass conditions (class) are illustrated in Tables 4.1 to 4.4.

Table 6.11 summarises the key assumptions for each opening and the stabilisation requirements, which include the following elements :

- Volume of temporary backfill
- Pillar or wall reconstruction
- Construction of walls and grouting of poor ground behind
- Volume of material to be removed
- Dewatering requirements

A single summary sheet is also provided for each ancient mine area in Appendix B. The sheets summarise and quantify all of the above together with the support requirements (rock bolts and mesh). These have been used as a basis for costing.

6.8.2 Provision of Permanent Walkways

Table 6.12 lists the extent of walkways that are required to be constructed within each of the ancient mine areas and defines whether they should be suspended or at grade. These distances can also be used as a measure of the distance materials need to be transported by hand to facilitate any of the measures required.

6.9 Annual Operating Costs

The annual operating costs of the mine need to consider as a minimum the following :

- Utilities
- Tourism Staff
- Mines Inspection and Maintenance
- Mines Rescue

7 BUDGET COST ESTIMATES

7.1 General

Given the size of the works required to convert the abandoned mine workings into a mine museum, it is assumed that, should this scheme proceed, it is likely to be undertaken by an international contractor due to its size and degree of complexity requiring a multi-discipline approach.

In the period given to consider the likely cost, it has not been possible to obtain local construction costs or to investigate the costs a multi-national company might encounter while working in Romania.

It is recognised that the application of unit rates without regard to the complexity of the work could lead to a significant under-estimate. The approach adopted here has therefore been to establish both material costs and labour costs and apply these via a measure of the quantities required and via a programme estimate for each element of the works in order to derive total labour costs. Even so, the conditions of access will require that much of the work is undertaken by hand and with hand transport of materials to many of the mine areas.

As noted previously, this scheme is likely to be undertaken by an international construction company and as such its costs are more likely to reflect UK costs rather than those of an indigenous Romanian contracting concern.

Labour rates in Romania are approximately 10% of UK rates. However, Romania has just joined the EU and wage rates are likely to rise progressively to the average European levels, especially if a major project such as the one envisaged proceeds under the management of an international construction company.

A priced Budget Activity Schedule is included as Tables 7.2 to 7.10. The major quantities are summarised in Appendix C and those for the mine museum in Appendix D.

7.2 Programme and Sequencing of the Work

No report, survey or photograph can properly describe the actual work which is likely to be faced by the construction company entrusted to undertake the work. In such a complicated mine base on 23 worked levels, safety and safe working practices will always have precedence over production targets.

A desk study indicates that several mining teams could undertake construction of the main roadways and accesses. However a more detailed study, when more information is made available, might preclude construction activities being undertaken in the sequence shown on the Budget Programme, with consequential impacts on cost.

It can be seen that, following the installation of all necessary construction services and access roads, the mine construction will be the critical activity to the scheme.

A Budget programme is included as Table 7.1.

The Budget programme was constructed from the Summary of Major Quantities and the assessment made of time durations shown on the table of Critical Path Activities Output, included as Appendix E.

7.3 Budget Cost Assessment - Mine Construction

The schedule has been priced based upon current contracting costs together with 25% on cost to cover site preliminaries and overhead costs.

The following forms the basis of the Budget unit costs:-

7.3.1 Labour Gangs

Based on 6 day week including attendance	**£/Wk**
Shaft gang (above ground)	33,800
Shaft gang (below ground)	37,620
Mining gang (Adits)	33,800
Mining gang (Room and Pillar Access)	27,160
Bulkhead construction	8,740
Grouting gang	33,120
Tracked Rig Drilling gang	33,600
Stone filling to Coranda	38,510
Remove stone and rockbolt Coranda via shaft	34,100
Remove stone and rockbolt Coranda via adit	38,590
Disposal of stone	4,625

7.3.2 Material Costs

Item	**£/Unit**
4.57 dia bolted shaft rings	1875/m
C40 Concrete	75/m^3
10:1 Sand grout	30/m^3
2.4m Rock bolt and mesh	175/each
10m Rock bolt and mesh	225/each
Sawn soft wood	240/m^3
Fabricated steelwork	1800/t

7.3.3 Mine Fitting Out

Ventilation

No detailed mine ventilation scheme has been developed for ventilation during the construction works or subsequently. However, Romanian mining rules require that each 250m of mine is to be vented by an 11kw fan.

On this basis, to vent the whole mine it would require approximately 30 fans of total power 330kw.

If a safety factor of 50% is added to this requirement and fans placed at 8 portal positions then each fan would require to be 60kw.

Lighting and Power

Lighting and power cabling together with telephone, CCTV cameras and alarm system will need to be installed for the complete length of the walkthrough.

The light fitting will contain an emergency backup system and possibly an air monitoring and equipment monitoring system will also be needed.

It has not been possible to assess the requirements for the substation or a standby generator system should mains supply be interrupted.

The electricity generating company should be approached to assess these costs more appropriately.

Dewatering

Isolated pockets of water are evident in a few parts of the mine. Water levels vary seasonally.

It would be prudent to install a small electric pump in a sump at each carnic with a float switch and delivery pipe to the nearest portal position for discharge.

Health and Welfare

It will be necessary to construct 2 underground rooms approximately 5m x 10m x 2.5 high to accommodate a rest room, toilet facilities and first aid position.

The cost allows for building the new welfare facility by increasing the size of the adit. However, a cost saving can be made if it is possible to utilise an existing section of the modern workings close to the desired position.

First Aid points will be located along the “Walk through” at regular intervals together with an appropriate alarm system.

Transport System

It is hoped that a rail system can be installed in Adit 1, between the maintenance entrance portal and Coranda Corhuri, to allow stop offs to view Carnic 1, 2 and 3.

Visitors will be led through the mine in dedicated parties and as such for the first part of the tour the train will have to stay with the party until they leave Adit 1 to view Carnic 3.

To increase the throughput of visitors, a two rail system in Adit 1 will be required with crossover points and “up and down” rail control. The total length of rail in Adit 1 will be in the order of 1000m.

A second rail system is also required in Adit 9 to service Carnic 5. This can be single rail operating a shuttle service.

Lifts and Walkways

Work will be undertaken to Footways in each Carnic to provide a suitably safe and graded access. It is envisaged that the floor will be graded out by placing concrete in low spots and trimming surfaces as necessary.

These lifts will need to be individually designed by the chosen manufacturer. A provisional figure has been inserted for the four lifts which should be considered as a lower bound cost.

7.4 Budget Cost Assessment - External Infrastructure Works

Slope Stabilisation

Limited investigation has been made of the route of the roadway through and adjacent to mine spoil tips.

This report identifies that 527,500m^3 of material is to be taken from various parts of the site to the Cetate open pit site.

The exact access route into the Cetate is not known and could be long and tortuous requiring significant temporary haul roads to be constructed; these have not been budgeted for. We have however assumed an average haul route of 1.5 - 2km for transportation cost estimation.

Stabilisation has therefore been assumed to be achieved solely by removal of material to form a reprofiled slope. The costs of any further stabilisation works (soil nailing, retaining structures etc), unknown at this present time, should be accommodated by the scheme contingency addition.

Access Road

The Budget allows for 6m wide tarmac road with kerbs and simple signage and drainage system where necessary. As this is a private road no foot paths will be provided.

Water Supply and Purification

The location and route of the water supply is not known.

The Budget allows for a 2km rising main, pumping station and purification plant. A secondary pumping main may be required to distribute the purified water to both the Visitor Centre and the mine facilities.

Water Treatment

It is assumed that the Visitor Centre will be connected to town’s main drainage system at little cost.

Foul water that arises from the activities at the Mine Centre will need to be treated.

Treating this foul water can be done in a number of ways from the installation of a small biological plant (RBC) with reed beds or using a septic tank system.

Power

It is assumed that the Visitor Centre will be connected to the existing mains supply of the town at little cost in comparison to the cost of the overall scheme.

It has not been possible to assess the power requirements of the Mine Centre. The electricity generating company should be approached to assess the requirements and costs more appropriately. No sum has been included in this budget estimate.

Communication

The Museum may require a land line telephone system or to adopt a different method of communication.

This element would need to be considered further by the Museum Authorities depending on their precise needs.

Museum Facilities

The requirements of the Visitor Centre and Mine Centre are not known at present.

An illustration of what could be envisaged is attached in file 'Rosia Montana Museum Buildings'.

The Budget allows for a full cost including design fees for a standard building. It does not include for the purchase of the land.

Mine Maintenance

The current rules governing Romanian mines are not known in detail. However, as Romania is now a part of the EU, the rules governing this mine are likely to be similar to those in the UK.

It would be envisaged therefore that a team would be set up to cover all aspects of mines inspection, maintenance and rescue. Added to this, all mine guides will be expected to be adequately trained and qualified to the appropriate First Aider standard.

It is anticipated that the mine will be open for visitors between 10am and 6pm, seven days a week all year round. This would require the mine to be vented, starting at 6am with an inspection lasting approximately 2 hours taking place around 7am - 9am. The mine would close for visitors around 6pm and the mine finally closed about 7pm.

A team would need to be available for at least 12 hours a day, seven days a week, i.e. 84 hours per week. A minimum of 6 men would be required for Mines Rescue.

Depending on current work practices and shift rotas, it is possible to set up two teams of 6 men and 2 supervisors to cover the needs of inspecting, maintaining and mine rescue if the men are also

qualified in building trades to carry out essential maintenance operations. Equipment and transport will also be required.

Wage and Salary costs will be dependant on the local labour market and experience available in the area.

The Budget gives an indication of the likely cost based on UK rates.

The teams would comprise:

Team 1: Mine Deputy
Mine Engineer
6 Man Rescue Team

Team 2: Mine Deputy
Assistant Mine Engineer
6 Man Rescue Team

There would also be sufficiently trained and skilled people employed by the Museum to cover for sickness and holiday periods.

The Mines Manager would be a part of the Museum Board and is therefore not considered to be a direct mine maintenance cost.

7.5 Exclusions from the Budget

This budget is based on preliminary information and initial assessments of requirements as presented in this Report. Once expanded by the Client, items and risks will be incorporated which could not be foreseen and costed at this present time.

It is always prudent to add a reasonable contingency sum to Budget assessments but in the case of this scheme, because of its complexity and the nature of work to be undertaken, it should be no less than an additional 50% of the budgeted work.

In addition, a sum of 10% should be allowed for investigation, survey, design and approvals.

Other items which have been specifically excluded are :

- Local Tax rates and VAT.
- Planning permission and restraints.
- Construction and maintenance of work sites for construction personnel including travel arrangements.
- Secure fencing of the site together with 24hr security arrangements.
- Museum equipment, personnel and fitting out of the buildings.
- Winter working conditions.
- Electricity Substation and Power Supply and communications.

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TABLES

TABLE 4.1

ROCK MASS CLASS	KEY FEATURES	RQD	Jn	Jr	Ja	Jw	SRF
CR 1	Poorly developed, subhorizontal structure Highly silicified, very strong rock	60 - 80	Few joints - one joint set	Discontinuous Joints	Tightly healed - Unaltered Joint walls	Dry excavations or minor inflow	Medium Stress, favourable stress conditions
CR 2	Poorly developed, subhorizontal structure Slightly silicified, moderately strong rock	50 - 60	One joint set	Discontinuous Joints - rough irregular	Unaltered Joint walls	Dry excavations or minor inflow	Medium Stress, favourable stress conditions
CR3	Well developed, thoroughgoing, subhorizontal clay in filled discontinuities. Slightly silicified, moderately strong rock	40 - 50	One joint set	Smooth planar	Thick continuous zones of clay	Dry excavations or minor inflow	Medium Stress, favourable stress conditions
CR 4	Poorly developed, subhorizontal structure Unsilicified, altered rock	10 to 30	One joint set plus random - Two joint sets	rough irregular	Silty or sandy clay coating	Moderate inflow	Low stress near surface
CR 5	Poorly developed, subhorizontal structure Un silicified, altered and highly weathered rock	5 - 10	One joint set plus random - Two joint sets	rough irregular	Softened or low friction clay mineral coatings	Moderate inflow	Low stress near surface

ROSIA MONTANA - MINE
ROCK MASS CLASSES - HORIZONTAL AND INCLINED OPENINGS - CROWN CONDITION - ANCIENT WORKINGS
Q ASSESSMENT - INPUT PARAMETERS

DOMAIN	RQD	Jn	Jr	Ja	Jw	SRF	Q calculation	Q Value	LOWER / UPPER BOUND
CR1	60 - 80	1 - 2	4	1	1	1	80/1 x 4/1 x 1/1	320	UB
							60/2 x 4/1 x 1/1	120	LB
CR2	50 - 60	2	4 - 3	2	1	1	60/2 x 4/2 x 1/1	60	UB
							50/2 x 3/2 x 1/1	37.5	LB
CR3	40 - 50	2	3	10	1	1	50/2 x 3/10 x 1/1	7.5	UB
							40/2 x 3/10 x 1/1	6.0	LB
CR4	10 to 30	2 - 4	4 - 3	3	0.66	2.5	30/2 x 4/3 x 0.66/2.5	5.3	UB
							10/3 x 3/3 x 0.66/2.5	0.8	LB
CR5	5 - 10	2 - 4	4 - 3	4	0.66	2.5	10/2 x 4/4 x 0.66/2.5	0.66	UB
							5/3 x 3/4 x 0.66/2.5	0.25	LB

Notes

1 Q calculated on the basis of Q = RQD/Jn x Jr/Ja x Jw/SRF, after Barton, Lein and Lunde (1974) and Barton and Grimstad (1994).

2 LB denotes Lower Bound and UB Upper Bound

ROSIA MONTANA - MINE
ROCK MASS CLASSES - HORIZONTAL AND INCLINED OPENNINGS - ANCIENT WORKINGS
CROWN STABILITY CONDITION - Q ASSESSMENT

ROCK MASS CLASS	KEY FEATURES	RQD	Jn	Jr	Ja	Jw	SRF
SW 1	Closely spaced, throughgoing, subvertical structure Highly silicified, very strong rock	60 - 80	One joint set	Smooth planar	Silty or sandy clay coating	Dry excavations or minor inflow	Medium Stress, favourable stress conditions
SW 2	Closely spaced, throughgoing, subvertical structure Slightly silicified, moderately strong rock	50 - 60	One joint set	Smooth planar	Silty or sandy clay coating	Dry excavations or minor inflow	Medium Stress, favourable stress conditions
SW 3	Widely spaced, throughgoing, subvertical structure Unsilicified, altered rock	10 to 30	One joint set plus random - Two joint sets	rough irregular	Silty or sandy clay coating	Moderate inflow	Low stress near surface
SW 4	Poorly developed, subhorizontal and subvertical structure Unsilicified, altered and highly weathered rock	5 - 10	One joint set plus random - Two joint sets	rough irregular	Softened or low friction clay mineral coatings	Moderate inflow	Low stress near surface

ROSIA MONTANA - MINE
ROCK MASS CLASSES - VERTICAL AND STEEPLY DIPPING STOPES - SIDEWALL CONDITION - ANCIENT WORKINGS
Q ASSESSMENT - INPUT PARAMETERS

TABLE 4.4

DOMAIN	RQD	Jn	Jr	Ja	Jw	SRF	Q calculation	Q Value	LOWER / UPPER BOUND
SW 1	60 - 80	2	1	3	1	1	80/2 x 1/3 x 1/1	13.3	UB
							60/2 x 1/3 x 1/1	10	LB
SW 2	50 - 60	2	1	3	1	1	60/2 x 1/3 x 1/1	10	UB
							50/2 x 1/3 x 1/1	8.3	LB
SW 3	10 to 30	3 - 4	4 - 3	3	0.66	2.5	30/3 x 4/3 x 0.66/2.5	3.5	UB
							10/4 x 3/3 x 0.66/2.5	0.66	LB
SW 4	5 - 10	3 - 4	4 - 3	4	0.66	2.5	10/3 x 4/4 x 0.66/2.5	0.88	UB
							5/4 x 3/4 x 0.66/2.5	0.25	LB

Notes

1 Q calculated on the basis of Q = RQD/Jn x Jr/Ja x Jw/SRF, after Barton, Lein and Lunde (1974) and Barton and Grimstad (1994).
2 LB denotes Lower Bound and UB Upper Bound

ROSIA MONTANA - MINE
ROCK MASS CLASSES - VERTICAL AND STEEPLY DIPPING STOPES - ANCIENT WORKINGS
SIDEWALL CONDITION - Q ASSESSMENT

TABLE 6.1

Road	Description	Length (m)	Additional Work
A-B	Access road from Rosia town square to mine tour main entrance (Portal 1 958m Level).	2105	Stabilisation of existing open pit mine workings and tailings dumps (marked with blue dashed lines on the above plan).
B-A	Exit road from Portal 1 to Rosia town square.	2750	Stabilisation of slopes bordering the sides of the proposed road.
B-C	Portal 1 to car park.	600	2000m^2 Car park at point C
C-D	Car park to Entrance for Carnic 9 & 10 (Portal 8)	200	Stabilisation of existing open pit mine workings, tailings dumps (marked with blue dashed lines) and slopes.
C-E	Car Park to 'Lookout Point'	475	Construction of the 'lookout Point'. Stabilisation of slopes/tailings dump (marked with blue dashed lines).
D-F	Portal 2 to 'Ring' road.	270	Stabilisation of slopes either side of the road.
D-G	Portal 2 to Carnic 21 & 22 entrance/exit (Portal 2)	310	Stabilisation of slopes either side of the road.
H-F	Carnic 13 entrance exit (Portal 7) to ring road.	110	Stabilisation of slopes either side of the road.
I-J	Carnic 2 & 3 emergency exit (Portal 5) to ring road.	200	Stabilisation of slopes either side of the road.
K-L	Carnic 5 emergency exit (Portal 6) to ring road.	350	Stabilisation of existing mine tailings dump (marked with blue dashed lines).
M-N	Ring road to emergency exit from Coranda Corhuri (Portal 3).	250	Stabilisation of very steep slopes either side of the road. Major engineering works required.
Total		**7620**	

ROSIA MONTANA MINE
MINE MUSEUM
ACCESS ROAD AND CAR PARK REQUIREMENTS

TABLE 6.2

Slope	Approximate Surface Area (m^2)	Description	Assumed thickness (m)	Reprofiling - material to removed (m^3)
A	22500	Tailings dump from modern Carnic mine workings. Must be traversed by access road.	3	67500
B	5000	Tailings dump from modern Carnic mine workings. Access rod cuts through toe of tip.	2	10000
C	-	Crest of slope associated with Cetata open pit. Access road passes adjacent to crest.	-	- stabilise slopes by backfilling that section of the pit.
D	30000	Tailings dump from modern Carnic mine workings. Tailings made up of Dacite and other gangue minerals. Spoil heap is above 932 entrance and directly below 958 entrance.	4	120000
E	25500	Tailings dump from modern Carnic mine workings. Tailings made up of Dacite and other gangue minerals.	2	51000
F	15000	Tailings dump from modern Carnic mine workings. Tailings made up of Dacite and other gangue minerals. Currently experiencing ongoing movement.	3	45000
G	17000	Tailings dump from modern Carnic mine workings. Tailings made up of Dacite and other gangue minerals.	2	34000
H	40000	Existing weathers and unstable slope. Road cuttings into the slope are unstable and weathered on both sides. Adjacent to Carnic 21 and 22.	2	80000
I	60000	Existing slope situated below the ring road and above a village. Slope appears unstable with numerous scree slopes. 25% of area to reprofiled	2	120000

Portal	Level (mOD)	Use	Other
P1 (Existing)	958	• Main entrance to the mine tour. • Pick up point for the electric train. • Adit leads towards the Coranda Corhuri, Room and Pillar workings and Carnic 1, 2 & 3.	• The adit leading from P1 to the Coranda Corhuri will be widened and lined with cast in-situ concrete. • The widened adit will have a cross sectional area of 8.5m^2.
P2 (New)	1000	• Exit from Carnic 21 & 22 via Shaft 2.	• The portal will be the surface point for Shaft 1. • The shaft will have a cross sectional area of 17.30m^2.
P3 (Existing)	958	• Emergency exit from the Coranda Corhuri and Room and Pillar workings.	• The adit leading from the Coranda Corhuri and the Room and Pillar workings will be widened and lined with cast in-situ concrete. • The adit will have a cross sectional area of 8.5m^2.
P4 (Existing)	853	• Emergency exit from Coranda Corhuri and Room and Pillar workings. • The adit emerging at P4 will be accessed from the Coranda Corhuri and Mine and Pillar workings via Shaft 3.	• The adit leading from Shaft 3 will be widened and lined with cast in-situ concrete. • The adit will have a cross sectional area of 8.5m^2.
P5 (Existing)	958	• Emergency exit from Carnic 1, 2 & 3.	• The adit leading from Carnic 1, 2 & 3 will be widened and lined with cast in-situ concrete. • The adit will have a cross sectional area of 8.5m^2.
P6 (Existing)	932	• Exit from Carnic 5 & 6.	• The adit leading from Carnic 5 & 6 will be widened and lined with cast in-situ concrete. • The adit will have a cross sectional area of 8.5m^2.
P7 (Existing)	960	• Emergency exit from Carnic 13, 21 & 22.	• The adit leading from Carnic 13, 21 & 22 will be widened and lined with cast in-situ concrete. • The adit will have a cross sectional area of 8.5m^2.
P8 (Existing)	978	• Entrance to Carnic 9 & 10.	• The adit leading from Carnic 9 & 10 will be widened and lined with cast in-situ concrete. • The adit will have a cross sectional area of 8.5m^2.
P9 (New)	1000	• Emergency exit from Carnic 9 & 10 via shaft 4.	• The portal will be the surface point for Shaft 1. • The shaft will have a cross sectional area of 17.30m^2.

ROSIA MONTANA MINE
MINE MUSEUM
PORTALS P1 – P9

TABLE 6.4

Shaft	From	To	Height (m)	Proposed Cross Sectional Area (m^2)	Shaft Volume (m^3)	Other
Shaft 1 (New)	Carnic 6 (932mOD)	Carnic 13 (960mOD)	28	17.3	484	• Connecting adit from 960mOD level to Carnic 13 network will need to be widened and stabilised (see Section 6). • Electric lift to be installed.
Shaft 2 (New)	Carnic 21 & 22 (960mOD)	Surface (1000mOD)	40	17.3	692	• Surface exit. Requires stabilisation. Link to the ring road to be constructed (see Section 3). • Electric lift to be installed. • Entrance from Carnic 21 & 22 will require stabilising and widening to accommodate the lift.
Shaft 3 (Existing)	Coranda Corhuri (958mOD)	Emergency exit adit (853mOD)	105	17.3	1817	• Existing shaft will need to be widened from 10.75m^2 and backfill removed from the bottom 30m. • The emergency exit adit will need to be widened and stabilised (see Section 6). • Electric lift to be installed.
Shaft 4 (New)	Carnic 10 (978mOD)	Surface (999mOD)	21	17.3	363	• Surface exit requires stabilisation and link to the ring road constructed (see Section 2). • Electric lift to be installed. • Entrance from Carnic 10 will require stabilising and widening to accommodate the lift.

ROSIA MONTANA MINE
MINE MUSEUM
SHAFTS – NEW AND EXISTING

TABLE 6.5.1

Adit	Level (mOD)	Description	Length (m)	Cross Sectional Area		Required Work
				Current (m^2)	Planned (m^2)	
1	958	Portal 1 to Shaft 3	400	6.8	8.5	• Adit will be widened and supported with cast in-situ concrete. • Electric rail system will be installed. Rail system must enable passengers to alight at adit to Carnic 1, 2 & 3 and Coranda Corhuri. • Adit is currently partially lined with stone blocks; these will need to be removed. • Spoil resulting from the archaeological excavations has also been deposited in this area; this will need to be removed. • Adit will require ventilation.
2	958	Shaft 3 to Coranda Corhuri South	45	6.5	8.5	• Adit will be widened and supported using cast in-situ concrete. • Adit will require ventilation.
3	958	Coranda Corhuri South to Coranda Corhuri North	175	6.5	7.3	• Adit will be widened and supported using cast in-situ concrete. • Adit will require ventilation.

ROSIA MONTANA MINE
MINE MUSEUM
INTERVENING ADITS – EXISTING ADITS – SUPPORT REQUIREMENTS
ADITS 1 - 3

TABLE 6.5.2

Adit	Level (mOD)	Description	Length (m)	Cross Sectional Area		Required Work
				Current (m^2)	Planned (m^2)	
4	853	Base of Shaft 3 to Portal 4	420	6.5	7.3	• Adit will be widened and supported using cast in-situ concrete. • Adit will require ventilation.
5	958	Room and Pillar to Portal 3	200	4.0	7.3	• Adit will be widened and supported using cast in-situ concrete. • Adit will require ventilation.
6	958	Adit 1 to Carnic 1	50	6.2	7.3	• Adit will be widened and supported using cast in-situ concrete. • Adit will require ventilation. • Junction between the two adits will require a platform for passengers to alight from the electric train.
7	958	Adit 1 to Carnic 3	190	6.2	8.5	• Adit will be widened and supported using cast in-situ concrete. • Adit will require ventilation. • Junction between the two adits will require a platform for passengers to alight from the electric train.
8	958	Adit 7 to Portal 5 (emergency exit from Carnic 3)	100	6.0	7.3	• Adit will be widened and supported using cast in-situ concrete. • Adit will require ventilation.

ROSIA MONTANA MINE
MINE MUSEUM
INTERVENING ADITS – EXISTING ADITS – SUPPORT REQUIREMENTS
ADITS 4 - 8

Adit	Level (mOD)	Description	Length (m)	Cross Sectional Area		Required Work
				Current (m^2)	Planned (m^2)	
9	932	Portal 6 towards Carnic 5	320	6.2	8.5	• Adit will be widened and supported with cast in-situ concrete. • Electric railway will be installed, platform for passengers to alight will be required at Carnic 5. • Adit will require ventilation.
10	932	Adit 9 to Carnic 5	160	6.2	7.3	• Adit will be widened and supported using cast in-situ concrete. • Adit will require ventilation.
11	932	Adit 10 to Carnic 6	195	6.0	8.5	• Adit will be widened and supported using cast in-situ concrete. • Adit will require ventilation.
12	932	Adit 9 to Carnic 6 and Shaft 1	50	-	8.5	• Adit will be advanced through unstable ground consisting of poor rock and collapsed mine workings. • Pre-grouting and temporary support of this area may be required. • Adit will be lined with cast in-situ concrete. • Adit will require ventilation.
13	960	Shaft 1 to Carnic 13	50	-	8.5	• Adit will be advanced through unstable ground consisting of poor rock and collapsed mine workings. • Pre-grouting and temporary support of this area may be required. • Adit will be lined with cast in-situ concrete. Adit will require ventilation.

ROSIA MONTANA MINE
MINE MUSEUM
INTERVENING ADITS – EXISTING ADITS – SUPPORT REQUIREMENTS
ADITS 9 - 13

TABLE 6.5.4

Adit	Level (mOD)	Description	Length (m)	Cross Sectional Area		Required Work
				Current (m^2)	Planned (m^2)	
14	960	Carnic 13 to Portal 7 (emergency exit from Carnic 13)	95	6.0	8.5	• Adit will be widened and supported using cast in-situ concrete. • Adit will require ventilation.
15	960	Carnic 13 to Carnic 21 & 22 and Shaft 2 (Portal 2)	70	5.8	8.5	• Adit will be widened and supported using cast in-situ concrete. • Adit will require ventilation.
16	978	Portal 8 to Carnic 9	80	6.2	8.5	• Adit will be widened and supported using cast in-situ concrete. • Adit will require ventilation. • Due to the angle of the adit there is an inflow of water that freezes in winter. • Portal will need to be re-engineered.
17	978	Carnic 9 to Carnic 10 and Shaft 4	50	6.3	8.5	• Adit will be widened and supported using cast in-situ concrete. • Adit will require ventilation.

ROSIA MONTANA MINE
MINE MUSEUM
INTERVENING ADITS – EXISTING ADITS – SUPPORT REQUIREMENTS
ADITS 14 – 17

TABLE 6.6

Level (mOD)	Mine Workings Location	Length (m)	Cross sectional area (m^2)	Volume of Backfill (m^3)
958	• Neighbouring mine workings off Adit 1.	250	7.30	1825
958	• Mine workings connecting from the room and pillar workings.	595	7.30	4344
958	• Mine workings connecting from Adit 7 on route to Carnic 3.	365	7.30	2665
932	• Mine workings connecting to Adit 9 on route to Carnic 5	30	7.30	219
932	• Mine workings connecting to Carnic 5 and Adit 10.	50	7.30	365
932	• Mine workings connecting to Adits 12& 13 and Carnic 6.	450	7.30	3285
960	• Mine workings connecting to Adit 13 on route to Carnic 13.	223	7.30	1628
960	• Mine workings connecting to Adit 15 on route to Carnic 22.	100	8.50	850
960	• Mine workings connecting with Carnic 21.	205	7.30	1497
960	• Mine workings connecting with Carnic 22.	165	7.30	1205
978	• Mine workings connecting to Carnic 9.	100	7.30	730

ROSIA MONTANA MINE
MINE MUSEUM
INTERVENING ADITS – EXISTING ADITS – BACKFILLING REQUIREMENTS
VARIOUS LEVELS

TABLE 6.7

Level	Length / Height	Required Work
Adit - 998	310	• Widen adit and stabilise using cast in situ concrete. • 55m in from the southwest the adit has been developed into room and pillar mine workings. These workings are 60.00m long with a void volume of 5056m^3. • The rooms in line with the adit would need to be kept open and supported, the following parameters apply: o Roof surface area = 180m^2 o Volume = 405m^3 • Temporary lighting and ventilation will be required.
Adit - 984	280	• Widen adit and stabilise using cast in situ concrete. • 70m in from the southwest the adit has been developed into room and pillar mine workings. These workings are 100m long with a void volume of 8427m^3. • The rooms in line with the adit would need to be kept open and supported, the following parameters apply: o Roof surface area = 300m^2 o Volume = 675m^3 o Bolt spacing of 2.0 - total number of bolts 75. Plus mesh. • Lighting and ventilation will be required. • Temporary lighting and ventilation will be required.
Adit - 958	340	• Widen adit and stabilise using cast in-situ concrete. • Lighting and ventilation will be required. • Temporary lighting and ventilation will be required.
Adit - 932	350	• Widen adit and stabilise using cast in-situ concrete. • Lighting and ventilation will be required. • Temporary lighting and ventilation will be required.
Shaft from Surface to crown	40	• Widen and stabilise shaft. • Lighting and ventilation will be required. • Temporary lighting and ventilation will be required.

TABLE 6.8.1

Level	Elevation (mOD)	Length of Room and Pillar Workings (m)	Approximate Height of Room and Pillar Workings (m)	Approximate Width of Room and Pillar Workings (m)	Total Volume of Room and Pillar Workings (m^3)	Volume of Pillars (Ratio of Rooms to Pillars approx 70:30) (m^3)	Volume of Backfill Required (m^3)
1	1023	50	2.25	53.50	6019	1806	4213
2	1008	42	2.25	53.50	5056	1517	3539
3	998	76	2.25	53.50	9149	2745	6404
4	995	56	2.25	53.50	6741	2022	4719
5	987	56	2.25	53.50	6741	2022	4719
6	983	101	2.25	53.50	12158	3647	8511
7	979	82	2.25	53.50	9871	2961	6910
8	973	98	2.25	53.50	11797	3539	8258
9	970	82	2.25	53.50	9871	2961	6910
10	958	140	2.25	53.50	16853	5056	11797
11	949	124	2.25	53.50	14927	4478	10449
12	942	124	2.25	53.50	14927	4478	10449
13	938	122	2.25	53.50	14686	4406	10280
14	933	140	2.25	53.50	16853	5056	11797

ROSIA MONTANA MINE
MINE MUSEUM
ROOM AND PILLAR MINE WORKINGS – BACKFILL VOLUMES – LEVELS 1 - 14

TABLE 6.8.2

Level	Elevation (mOD)	Length of Room and Pillar Workings (m)	Approximate Height of Room and Pillar Workings (m)	Approximate Width of Room and Pillar Workings (m)	Total Volume of Room and Pillar Workings (m^3)	Volume of Pillars (Ratio of Rooms to Pillars approx 70:30) (m^3)	Volume of Backfill Required (m^3)
15	929	88	2.25	53.50	10593	3178	7415
16	921	84	2.25	53.50	10112	3034	7078
17	912	120	2.25	53.50	14445	4334	10112
18	902	46	2.25	53.50	5537	1661	3876
19	898	54	2.25	53.50	6500	1950	4550
20	887	84	2.25	53.50	10112	3034	7078
21	882	48	2.25	53.50	5778	1733	4045
22	872	32	2.25	53.50	3852	1157	2696
23	863	20	2.25	53.50	2408	722	1685

ROSIA MONTANA MINE
MINE MUSEUM
ROOM AND PILLAR MINE WORKINGS – BACKFILL VOLUMES – LEVELS 15 – 23

TABLE 6.9

Level	Elevation (mOD)	Length of Room and Pillar Workings (m)	Approximate Height of Room and Pillar Workings (m)	Approximate Width of Room and Pillar Workings (m)	Total Volume of Room and Pillar Workings (m^3)	Volume of Pillars (Ratio of Rooms to Pillars approx 70:30) (m^3)	Volume of Backfill Required (m^3)
1	1018	45.00	2.25	53.50	5417	1625	3792
2	1010	30.00	2.25	53.50	3611	1083	2528
3	104	60.00	2.25	53.50	7223	2167	5056
4	998	60.00	2.25	53.50	7223	2167	5056
5	991	55.00	2.25	53.50	6621	1986	4634
6	984	100.00	2.25	53.50	12038	3611	8426
7	979	45.00	2.25	53.50	5417	1625	3792
8	973	35.00	2.25	53.50	4213	1264	2949
9	970	50.00	2.25	53.50	6019	1806	4213
10	958	30.00	2.25	53.50	3611	1083	2528

ROSIA MONTANA MINE
MINE MUSEUM
SOUTHWEST ROOM AND PILLAR MINE WORKINGS – BACKFILL VOLUMES

TABLE 6.10

Level Number	Level (mOD)	Access			
		Adit Length to Surface (m)		Shaft 1 Height (m)	Shaft 2 Height (m)
		South West	North East		
1	1023	No Adit	50.00	No Shaft	No Shaft
2	1008	No Adit	No Adit	15.00	No Shaft
3	998	No Adit	80.00	10.00	10.00
4	995	No Adit	No Adit	3.00	3.00
5	987	No Adit	No Adit	8.00	8.00
6	983	No Adit	No Adit	4.00	4.00
7	979	No Adit	No Adit	4.00	4.00
8	973	No Adit	No Adit	6.00	6.00
9	970	No Adit	No Adit	3.00	3.00
10	958	375.00	105.00	12.00	12.00
11	949	No Adit	No Adit	9.00	9.00
12	942	No Adit	No Adit	7.00	7.00
13	938	No Adit	No Adit	4.00	4.00
14	933	410.00	165.00	5.00	5.00
15	929	No Adit	No Adit	4.00	4.00
16	921	No Adit	No Adit	8.00	8.00
17	912	No Adit	210.00	9.00	9.00
18	902	No Adit	No Adit	10.00	No Shaft
19	898	No Adit	No Adit	4.00	No Shaft
20	887	No Adit	260.00	11.00	No Shaft
21	882	No Adit	No Adit	5.00	No Shaft
22	872	No Adit	No Adit	10.00	No Shaft
23	863	No Adit	No Adit	9.00	No Shaft

ROSIA MONTANA MINE - MINE MUSEUM
ROOM AND PILLAR MINE WORKINGS
CONNECTING ADITS AND SHAFTS – LEVELS 1 - 23 - REQUIRING SUPPORT TO FACILITATE TEMPORARY ACCESS FOR BACKFILLING OPERATION

TABLE 6.11

	CURNIG REFERENCE													
	1L	1M	1U	2L	2M	2U	2C (SW)	2C (CR)	3L	3M	3M	3U	5	6
SH / SV	SH	SH	SH	SH (Adit)	SH	SH (Adit)	SV (Cor.)	SH (Cor)	SH (Adits)	SH (Adits- G11, 20)	SH	SH (+G2)	SV (Cor.)	SV
Span (m)	**7**	**12**	**10**	**2**	**10**	**2**	(2.5)	**5**	**1.5**	**1.5**	**8 - 15 (<5)[2]**	**10**	(2)	**25**
Height (m)	(1.5)	(3)	3 - 6	(2)	(2 - 3)	(2)	**9**	(2.5)	(1.5)	(1.5) locally 3	(2.5)	(4)	**5 - 7**	(2)
Rock Mass Class	CR3	CR2	CR2	CR2	CR2	CR2	SW2	CR2	CR2	CR2 - Typical CR4 - eastern part of G11	CR4	CR4	SW2	SW2
Q max	(7.5)	(60)	(60)	(60)	(60)	(60)	(10)	(60)	(60)	(5.3)	(5.3)	(5.3)	(10)	(10)
Q min	**6.0**	**37.5**	**37.5**	**37.5**	**37.5**	**37.5**	**8.3**	**37.5**	**37.5**	**0.8**	**0.8**	**0.8**	**8.3**	**8.3**
Support Category	4 (5)	4	3	1	3	1	4	3 (+mesh)	1	4	5 (&6)	6(&7)	4	5
Pillar / Wall reconstruction ?	-	3 pillars	3 pillars (6m high)	-	-	-	-	-	-	-	3 pillars (2x2m)	2 pillars (2x2m)	N	N
Consolidation Grouting of adjacent backfill + wall if required	-	-	-	-	-	-	-	-	Rebuild 6m high (timber propped) Grout 6x2x4	-	Perimeter wall 45m long x2 and grout 15x5x2.5	-	12m high 2m wide scree slope walls + grout 12x2x5	N
Volume to be dug out	-	12x6x3	10x2x1.5 10x2x2.5	-	1x3x7 1x1.5x5[(3)]	-	-	-	-	-	-	-	-	
Area for support	12x7 4x18	12x6 10x8[(3)] 5 x16	6x10 10x15 7.5x8.5	-	10x10 5x5	-	7x9 7x9	5x7x2	-	8x1.5x3 (to be lined)	10x12	10X10 4X4	15X10 15X10	20X40 20X40
Dewatering	Y(D10)	N	Y (D17)	N	N	N	N	N	Y	N	N	N	N	N

TABLE 6.11 (cont)

	CURNIG REFERENCE										
	9L	9U	10L	10M	10U/I	13	21	22	G101+D17	9M	9C
SH / SV	SH	SH	SH	SH	SH	SH (Adit)	SV	SV	SV (adit)	SV	
Span (m)	**6**	**4**	**8**	**8**	**(12-16) D2= 6**	1.5	(4)	(4)	(2m)	(2)	
Height (m)	(2 ?)	(2)	(2)	(2)	(2)	(1.5)	15	12	6	6	
Rock Mass Class	CR4	CR4	CR2	CR4	CR4	CR2 (CR4)	SW1* (=CR1)	SW1* (=CR1)	SW2	SW2	
Q max	**5.3**	**5.3**	60	**5.3**	(5.3)	(60) (5.3)	320	320	(10)	(10)	
Q min	(0.8)	(0.8)	**37.5**	(0.8)	**0.8**	**37.5 (0.8)**	**120**	**120**	8.3	8.3	
Support Category	4	4	3	6	(3 - 4) D2=6	1 (4)	2	2	4	4	
Pillar / Wall reconstruction ?	-	-	10 pillars 1.5x1x2	2 pillars Wall L=15 + 8m	Wall L=45 3 Pillars	-	4 Horizontal Pillars 2x2x4	4 Horizontal Pillars 2x2x4	1 horizontal pillar 5mhigh x1x1	-	
Consolidation Grouting of adjacent backfill + wall if required	Wall 15x2 Grout 2x15x3 Fill Shaft 12x1.5x1.5	-	Build walls along and grout behind : Lower Wall 30x4, grout 10x4x5 Mid wall 6x1.5 grout 6x1.5x5 Mid wall 10x1.5 grout 10x1.5x5			Rebuild timber wall 10x2m and grout 10x2x4	-	-	-	-	
Volume to be dug out	-		5x2.5x10(L), 1x3x7(i), 6x6x10 (m) all out via Curnig 9 (150m)			-	-	-	-	-	
Area for support	6x6 4x3 2x2	4x4x1 (Also 20m portal adit)	7x8 5x5	7x10	D2 only 6x12	15x1.5 (SC4)	40x20 40x20	40x12x2	15x6 15x6	**5x5 5x5**	45m 'New Tunnel'
Dewatering	Y	N	N	N	N	N	N	N	N	N	N

NOTES :

1. Including areas not yet dug out by archeological diggings.
2. Effective span after reconstruction of pillars - walls
3. Stabilisation of associated modern re-working

ROSIA MONTANNA - MINE
ANCIENT WORKINGS - KEY TYPICAL ATTRIBUTES
INFERRED SUPPORT CATEGORY

TABLE 6.12

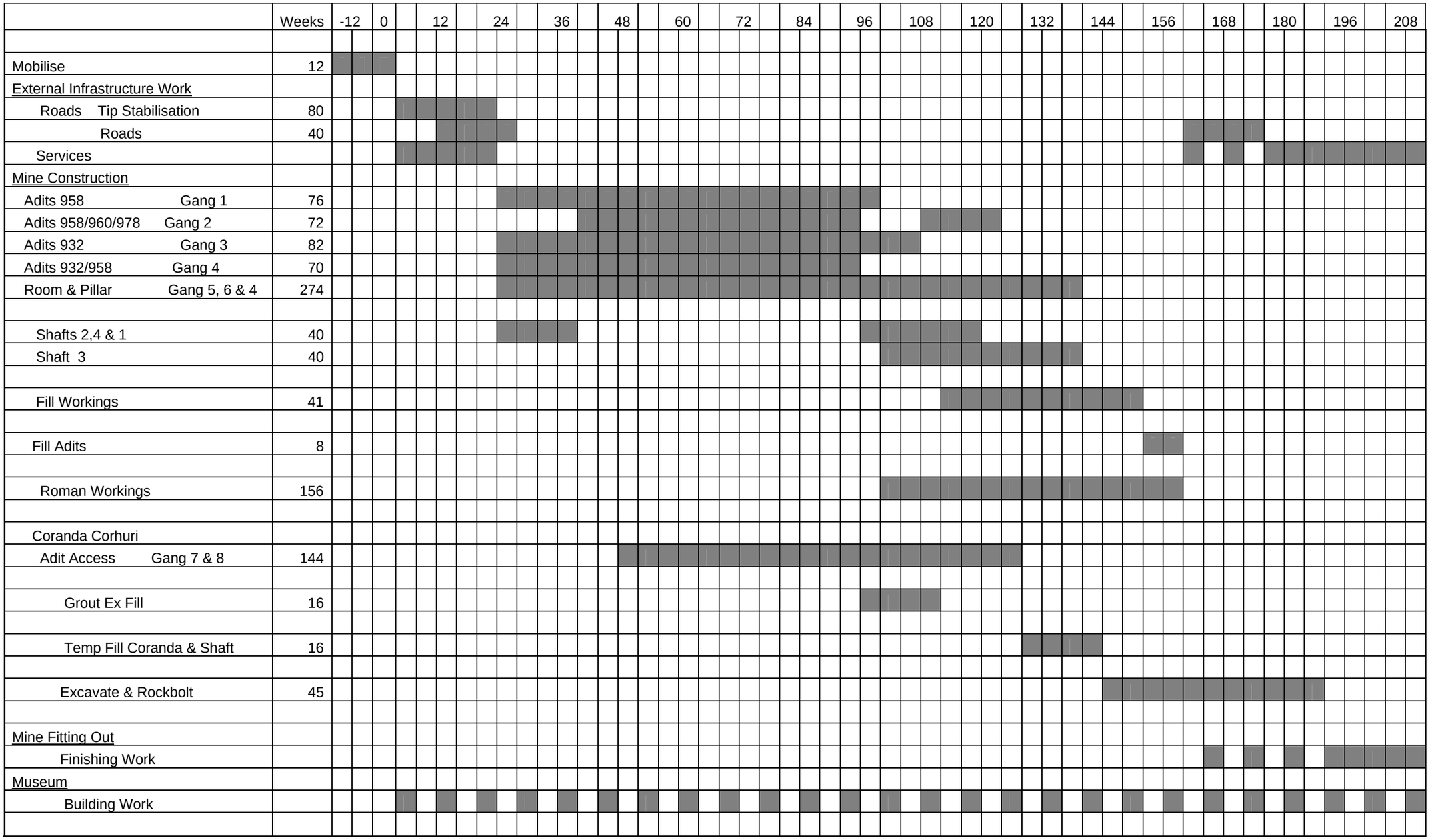
Carnic	Access Route	Footpath (m)	Suspended Footpath (m)	Stairs (linear m)	Other
Carnic 1 Upper	Access via stairs up from Carnic 1 Middle, exit is via the same route.	26.0	7.0	4.0	• Staircases will need to have incremental platforms due to the confines of the workings (approx 3.0 x 2.5m)
Carnic 1 Middle	Access into Carnic from Adit 6, exit via the same route.	85.5	7.0	7.0	• Staircases will need to have incremental platforms due to the confines of the workings (approx 4.0 x 3.0m)
Carnic 1 Lower	Access into Carnic 1 Lower from Carnic 2 Middle using Adit 6, exit via same route towards Carnic 5.	75.0	-	47.5	• $4m^2$ viewing platform required to look out over the Carnic 1 workings and act as a security barrier for 4m length of footpath.
Carnic 2 Upper	Access into Carnic 2 Upper via Adit 7, Exit via the same route.	131	3.0	11.0	• Stairs leading down from Carnic 2 Upper to Carnic 2 Middle through the Carnic 2 Coranda will need overhead protection over the entire length of stairs (8.0m).
Carnic 2 Middle	Access via stairs from Carnic 2 Upper. Exit via Carnic 1 Lower or Carnic 2 Upper.	36	5	9.0	
Carnic 3 Upper	Access into Carnic 3 Upper via Adit 7. Exit via the same route or down to Carnic 2 Middle.	147	-	6.0	
Carnic 3 Middle	Access via stairs down from Carnic 3 Upper. Exit via same route or down to Carnic 3 Lower.	111	-	6.0	
Carnic 3 Lower	Access via stairs down from Carnic 3 Middle. Exit via the same route.	42	5	-	

ROSIA MONTANA MINE
MINE MUSEUM
PROVISION OF PERMANENT WALKWAYS

Carnic	Access Route	Footpath (m)	Suspended Footpath (m)	Stairs (linear m)	Other
Carnic 5	Access via Adit 10. Exit via the same route.	14.0	-	4.0	
Carnic 6	Access via Adit 12 or Adit 11. Exit via same route or Shaft 1.	62	-	6.0	• Dewatering of 5.0m of adit is required before a permanent walkway can be established.
Carnic 9 Lower	Access via Carnic 9 Upper. Exit via the same route or Adit 17 towards Carnic 10.	25	-	6.0	
Carnic 9 Upper	Access from surface via Adit 16. Exit via same route or via stairs down to Carnic 9 Lower.	34	-	2.0	
Carnic 10 Lower	Access via Adit 17, exit via the same route or Carnic 10 Upper and Shaft 4 to surface.	40	-	7.0	
Carnic 10 Middle	Access via Carnic 10 Lower. Exit via same route or Shaft 4 to surface (Portal 9).	26	-	1.0	• Access from Carnic 10 Lower to Carnic 10 Middle is via the 40˚ dipping stope.
Carnic 10 Upper	Access via Carnic 10 Middle. Exit via the same route.	29	-	2.0	
Carnic 13	Access via Adit 13 leading from Shaft 1 or Adit 14 leading from Portal 7. Exit via the same routes or Adit 15 towards Carnic 21 & 22.	25	-	1.0	• Hand rails will be required for walkways due to gradient of the existing path.
Carnic 21	Access via Adit 15. Exit via the same route or by Shaft 2 to surface (Portal 2).	60	-	8.0	
Carnic 22	Access via Adit 15. Exit via the same route or via Shaft 2 located in Carnic 21.	60	-	-	

TABLE 7.1

	Weeks
Mobilise	12
External Infrastructure Work	
Roads Tip Stabilisation	80
Roads	40
Services	
Mine Construction	
Adits 958 Gang 1	76
Adits 958/960/978 Gang 2	72
Adits 932 Gang 3	82
Adits 932/958 Gang 4	70
Room & Pillar Gang 5, 6 & 4	274
Shafts 2,4 & 1	40
Shaft 3	40
Fill Workings	41
Fill Adits	8
Roman Workings	156
Coranda Corhuri	
Adit Access Gang 7 & 8	144
Grout Ex Fill	16
Temp Fill Coranda & Shaft	16
Excavate & Rockbolt	45
Mine Fitting Out	
Finishing Work	
Museum	
Building Work	



ROSIA MONTANA MINE
MINE MUSEUM
BUDGET PROGRAMME

Table /Ref	Section	Item	Quantity	Unit	Rate	£ Amount	Euro Rate	Euro Amount
								£ = 1.48 Euro
5	Portals	P1, P3, P4, P5, P6, P7, P8,	7	Nr	10,000	70,000	14,800.00	103,600.00
		P2, P9	2	Nr	15,000	30,000	22,200.00	44,400.00
6	Shafts	S1 - 4.57 dia, 28m deep	1	Nr	579,180	579,180	857,186.40	857,186.40
		S2 - 4.57 dia, 40m deep	1	Nr	582,680	582,680	862,366.40	862,366.40
		S3 - 4.57 dia,105m deep	1	Nr	1,701,675	1,701,675	2,518,479.00	2,518,479.00
		S4 - 4.57 dia, 21m deep	1	Nr	420,135	420,135	621,799.80	621,799.80
		Coranda Access 4.57 dia, 40m deep	1	Nr	519,220	519,220	768,445.60	768,445.60
		Disposal of Material	3895	m3	11	42,845	16.28	63,410.60
7	Adits	A1, A2, A7, A9, A12 - A17	1545	m	5,050	7,802,250	7,474.00	11,547,330.00
		A3, A4, A5, A6, A8, A10	1105	m	5,000	5,525,000	7,400.00	8,177,000.00
		Disposal of Material	18764	m3	11	206,404	16.28	305,477.92
		Pre grout materials Adits 12 +13	300	m3	125	37,500	185.00	55,500.00
					Page Total	**17,516,889**		**25,924,995.72**

ROSIA MONTANA
MINE MUSEUM
BUDGET ACTIVITY SCHEDULE – MINE CONSTRUCTION – PAGE 1

TABLE 7.3

Table /Ref	Section	Item	Quantity	Unit	Rate	£ Amount	Euro Rate	Euro Amount
7.2	Backfill Ex Adits	Level 958	8834	m3	44	388,696	65.12	575,270.08
		Level 932	3869	m3	44	170,236	65.12	251,949.28
		Level 960	5180	m3	44	227,920	65.12	337,321.60
		Level 978	730	m3	53	38,690	78.44	57,261.20
		Bulkheads	360	m2	482	173,520	713.36	256,809.60
8.1.2	Room & Pillar	Access Adits to workings	1655	m	1,960	3,243,800	2,900.80	4,800,824.00
		Shafts between workings	256	m	2,690	688,640	3,981.20	1,019,187.20
		Grout workings Level 1 -9 /1 -10	91157	m3	37	3,372,809	54.76	4,991,757.32
		Grout workings Level 11 - 23	91510	m3	37	3,385,870	54.76	5,011,087.60
		Bulkheads	1905	m2	482	918,210	713.36	1,358,950.80
9.1	Roman Workings	Rockbolting and Pillar construction		Item		4,161,360		6,158,812.80
		Rockbolt and mesh	1153	Nr	175	201,775	259.00	298,627.00
		grout	3000	m3	125	375,000	185.00	555,000.00
		concrete	900	m3	75	67,500	111.00	99,900.00
		Disposal of Material	5016	m3	11	55,176	16.28	81,660.48
		Carnic 9C Tunnel	45	m	5,000	225,000	7,400.00	333,000.00
					Page Total	**17,694,202**		**26,187,418.96**

TABLE 7.4

Table /Ref	Section	Item	Quantity	Unit	Rate	£ Amount	Euro Rate	Euro Amount
8	Coranda Corhuri	Access Adits to Coranda	1280	m	5,000	6,400,000	7,400.00	9,472,000.00
		Support Adj workings	480	m2	584	280,320	864.32	414,873.60
		Grout fill below Level 958	73010	m3	37	2,701,370	54.76	3,998,027.60
		Temporary Stone Fill	78225	m3	12	938,700	17.76	1,389,276.00
		Excavate Stone & Rockbolt	78225	m3	21	1,642,725	31.08	2,431,233.00
		Rockbolts and mesh	1540	Nr	225	346,500	333.00	512,820.00
		Disposal of Material	78225	M3	8	625,800	11.84	926,184.00
					Page Total	**12,935,415**		**19,144,414.20**
					Mine Construction Total	**48,146,506**		**71,256,828.88**

ROSIA MONTANA
MINE MUSEUM
BUDGET ACTIVITY SCHEDULE – MINE CONSTRUCTION – PAGE 3

TABLE 7.5

Table /Ref	Section	Item	Quantity	Unit	Rate	£ Amount	Euro Rate	Euro Amount
	Ventilation	Portal Fans c/w ducting	8	Nr	30,000	240,000	44,400.00	355,200.00
		Doors	9	Nr	8,000	72,000	11,840.00	106,560.00
	Lighting & Power	Cable & Fittings	7600	m	75	570,000	111.00	843,600.00
	& Communication							
		Substation / Generator House	1	Nr		by Others		by Others
	Dewatering	Electric Pumps & Pipework	10	Nr	6,500	65,000	9,620.00	96,200.00
	Health, Welfare	First Aid /Welfare Room	2	Nr	50,000	100,000	74,000.00	148,000.00
		First Aid points & signage	10	Nr	1,000	10,000	1,480.00	14,800.00
	Transport	Rail System	1400	m	150	210,000	222.00	310,800.00
		Traction Unit and Rolling Stock	2	Item	270593	541186.00	400,478.00	800,956.00
	Lifts & Walkways	Footways	1029	m	280	288,120	414.40	426,417.60
		Susp Walkways	27	m	910	24,570	1,346.80	36,363.60
		Stairs	128	m	1,820	232,960	2,693.60	344,780.80
		Lifts	4	Nr	100,000	400,000	148,000.00	592,000.00
					Total	**2,753,836**		**4,075,678.00**

TABLE 7.6

Table /Ref	Section	Item	Quantity	Unit	Rate	£ Amount	Euro Rate	Euro Amount
	Roads	Tip Stabilisation	527500	m3	4	2,110,000	5.92	3,122,800.00
		Access Roads	7620	m	600	4,572,000	888.00	6,766,560.00
	Water	Water supply	2000	m	160	320,000	236.80	473,600.00
		Water Purification & Pumping Station		Item		1,000,000		1,480,000.00
		Water Treatment		Item		600,000		888,000.00
	Power	installation		Item		by Others		by Others
	Communication	installation		Item		by Others		by Others
					Total	**8,602,000**		**12,730,960.00**

ROSIA MONTANA
MINE MUSEUM
BUDGET ACTIVITY SCHEDULE – EXTERNAL INFRASTRUCTURE WORK

TABLE 7.7

Table /Ref	Section	Item	Quantity	Unit	Rate	£ Amount	Euro Rate	Euro Amount
	Visitors Centre		3150	m2	972	3,061,800	1,438.56	4,531,464.00
	Mine Access Buildings	2 Buildings at P1, P2 & Stores	1250	m2	972	1,215,000	1,438.56	1,798,200.00
	Carparking		200	Nr	1,000	200,000	1,480.00	296,000.00
	Landscaping etc			Item		200,000		296,000.00
					Total	**4,676,800**		**6,921,664.00**

ROSIA MONTANA
MINE MUSEUM
BUDGET ACTIVITY SCHEDULE – MUSEUM FACILITIES

Table /Ref	Section	Item	Quantity	Unit	Rate	£ Amount	Euro Rate	Euro Amount
	Safety & Rescue		1	Year	673,000	673,000	996,040.00	996,040.00
	Maintenance	materials only	1	Year	50,000	50,000	74,000.00	74,000.00
					Total	**723,000**		**1,070,040.00**

ROSIA MONTANA
MINE MUSEUM
BUDGET ACTIVITY SCHEDULE – MINE MAINTENANCE

TABLE 7.9

Area	Section	Item	Unit	Quantity	Rate (Euro)	Amount (Euro)
Mine Stabilisation						
Level 958	Portals	P1,P3,P5	Nr	3	14800	44,400
	Adits		m	1160	7580	8,792,800
	Backfill Existing Adits		m^3	8834	80	706,720
Level 853	Portals	P4	Item	1	14800	14,800
	Shafts	S3	Item	-	-	2,518,479
	Adits		m	420	7580	3,183,600
Level 932	Portal	P6	Item	1	14800	14,800
	Adits		m	725	7580	549,500
	Shaft	S1	Item	-	-	857,188
	Backfill Existing Adits		m^3	3869	80	309,520
Level 960	Portal	P7	Item	1	14800	14,800
	Portal	P2	Item	1	22200	22,200
	Adits		m	215	7580	1,629,700
	Shaft	S2	Item	-	-	862,366
	Backfill Existing Adits		m^3	5180	80	414,400
Level 978	Portal	P8	Item	1	14800	14,800
	Portal	P9	Item	1	22200	22,200
	Adits		m	130	7580	985,400
	Shaft	S4	Item	-	-	621,600
	Backfill Existing Adits		m^3	730	80	58,400
Mine Stabilisation – Ancient Workings						
Carnics	All Carnics		Item	-	-	7,526,999
Mine Stabilisation – Modern Workings						
Coranda Corhuri	Adits		m	1280	7400	9,472,000
	Stabilise Walls and Roof		Item	-	-	9,673,413
	Shaft		Item	-	-	768,445
Room and Pillar	Adits to workings		m	1655	2901	4,801,155
	Shafts to Workings		m	256	3981	1,019,136
	Adjacent workings		m^3	139693	62	8,660,966
	South West Workings		m^3	42974	62	2,664,388
					Total	**71,256,828**

ROSIA MONTANA MINE
MINE MUSEUM
BUDGET ACTIVITY SCHEDULE – SUMMARY TABLE 1

TABLE 7.9

Area	Section	Item	Unit	Quantity	Rate (Euro)	Amount (Euro)
Additional Works						
Other	Mine Fitting out		Item			4,075,678
	External Infrastructure		Item			12,730,960
	Museum Facilities		Item			6,921,644
					Total	**94,985,110**
	Investigation, design, survey and approvals		%	10%		9,498,511
	Contingencies		%	50%		47,492,555
				Total Construction Costs		**151,976,176**

NB: Total Construction Cost does not include the cost of the Electricity Substation, Power Supply or Communications.

ROSIA MONTANA MINE
MINE MUSEUM
BUDGET ACTIVITY SCHEDULE – SUMMARY TABLE 1

TABLE 7.10

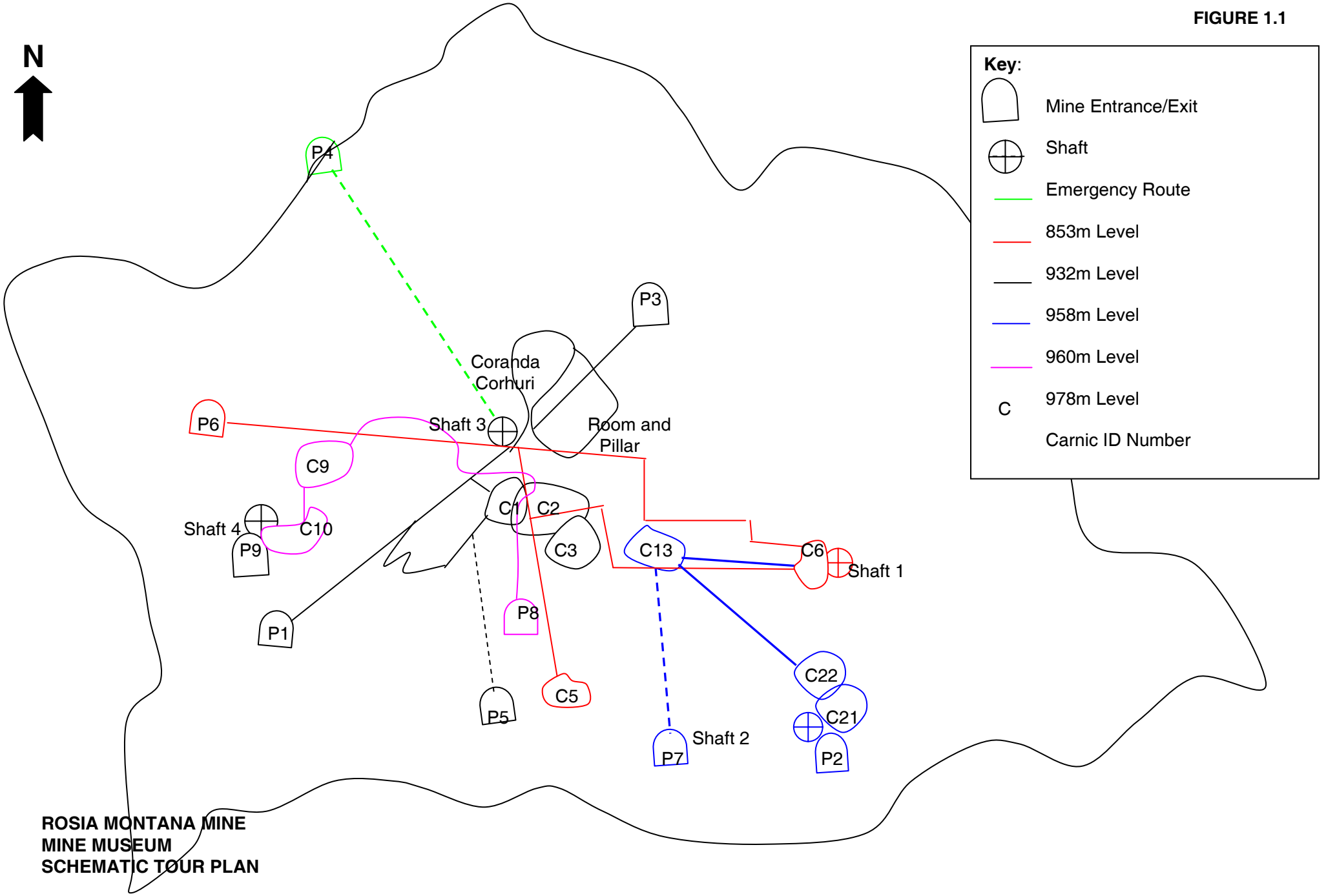
Table /Ref	Section	Item	Quantity	Unit	Rate	£ Amount	Euro Rate	Euro Amount
	Mine Construction					48,146,506		71,256,828.88
	Mine Fitting Out					2,212,650		4,075,678
	External Infrastructure					8,602,000		12,730,960.00
	Museum Facilities					4,676,800		6,921,664.00
						63,637,956		**94,985,110**
	Investigation, Design, Survey and approvals		10%			6,363,795		9,498,511
	Contingencies		50%			31,818,978		47,492,555
		Total Construction Costs				**101,820,729**		**151,976,176**
	Mine Maintenance	**Annual Costs**				**723,000**		**1,070,040.00**

NB: Total Construction Cost does not include the cost of the Electricity Substation, Power Supply or Communications.

ROSIA MONTANA MINE
MINE MUSEUM
BUDGET ACTIVITY SCHEDULE – SUMMARY TABLE 2

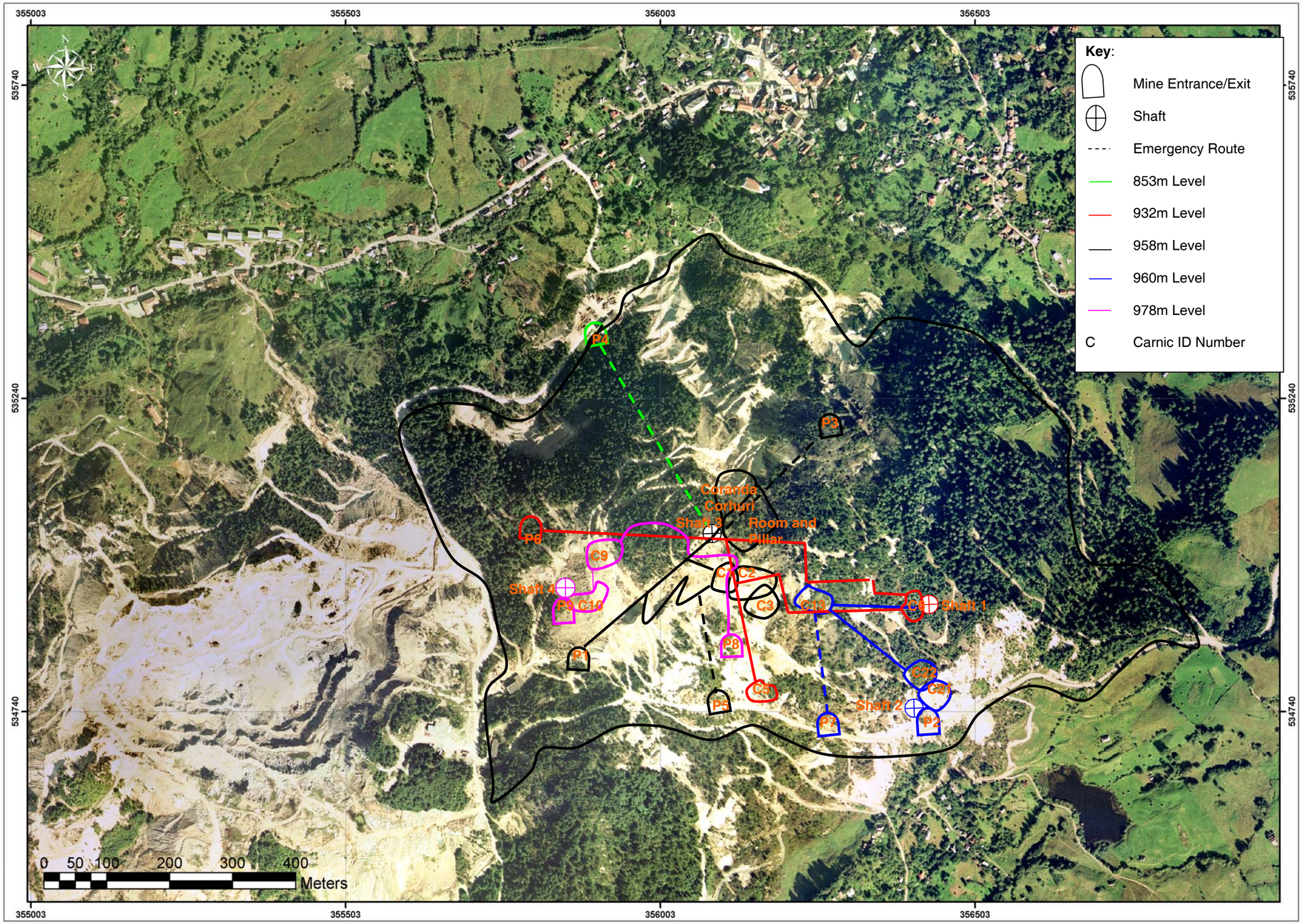
FIGURES

FIGURE 1.1



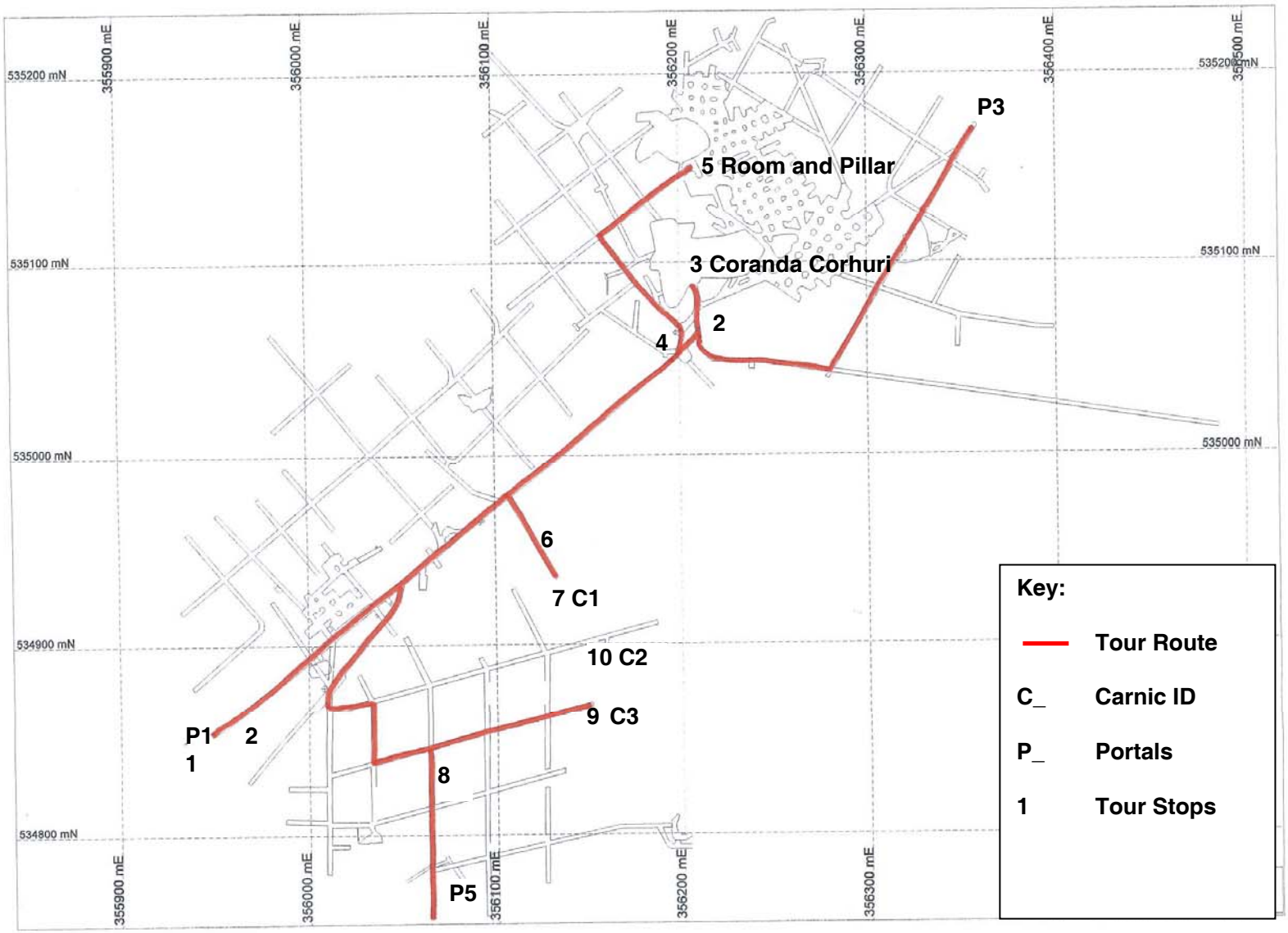
ROSIA MONTANA MINE
MINE MUSEUM
SCHEMATIC TOUR PLAN

FIGURE 1.2



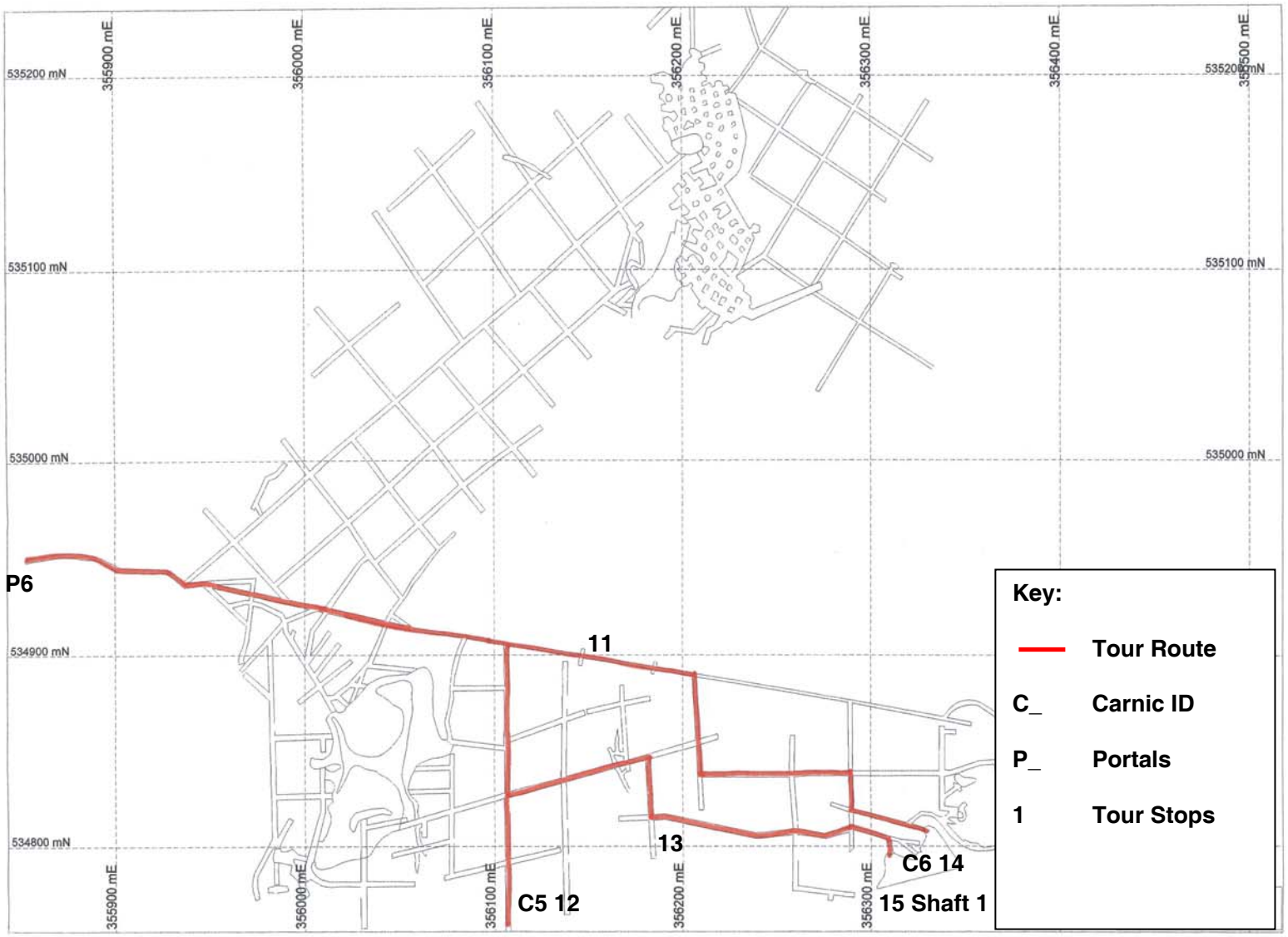
ROSIA MONTANA MINE
MINE TOUR PLAN - ARIAL PHOTOGRAPH OVERLAY

FIGURE 5.1



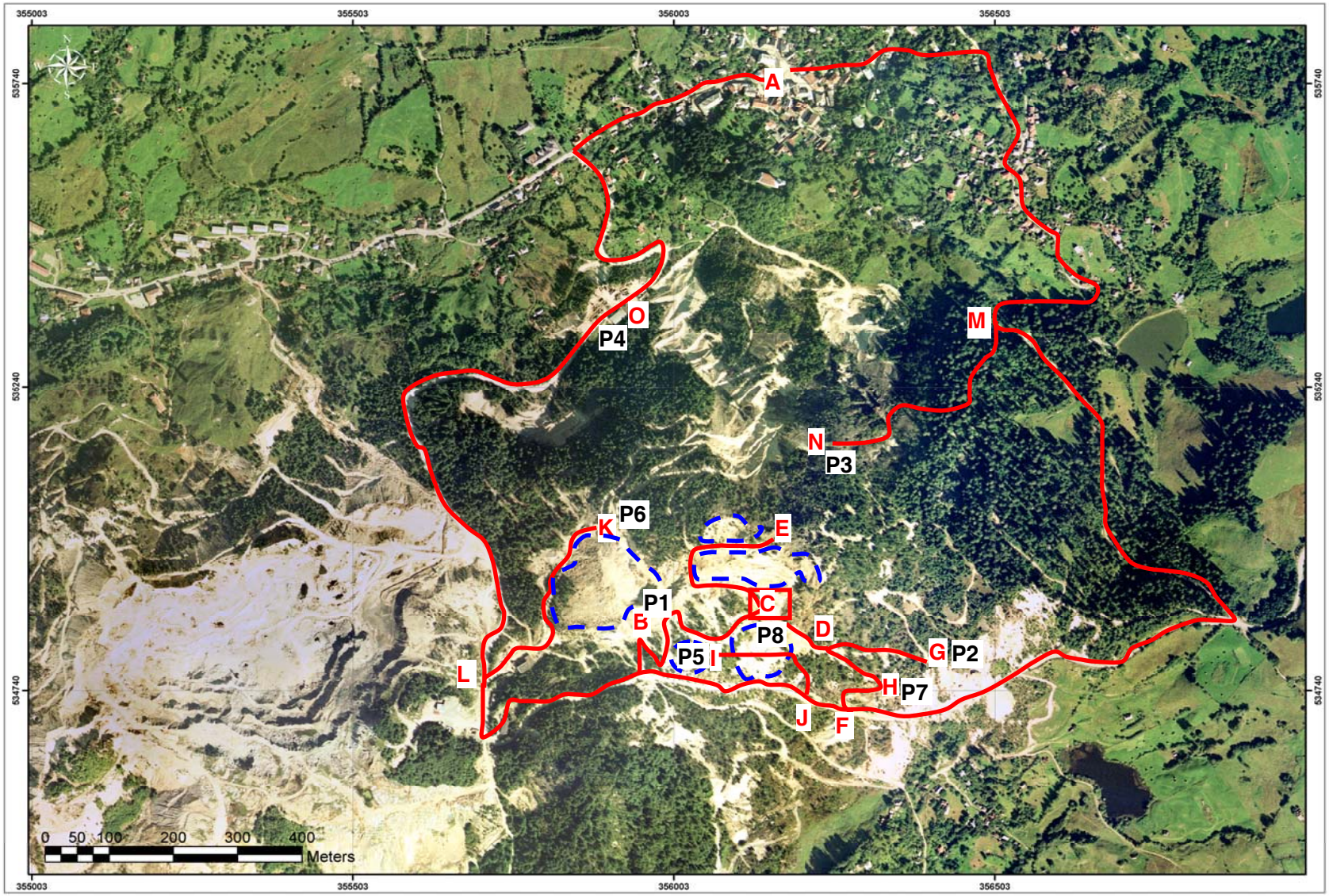
ROSIA MONTANA MINE
MINE MUSEUM
LAYOUT OF MODERN WORKINGS - LEVEL 958

FIGURE 5.2



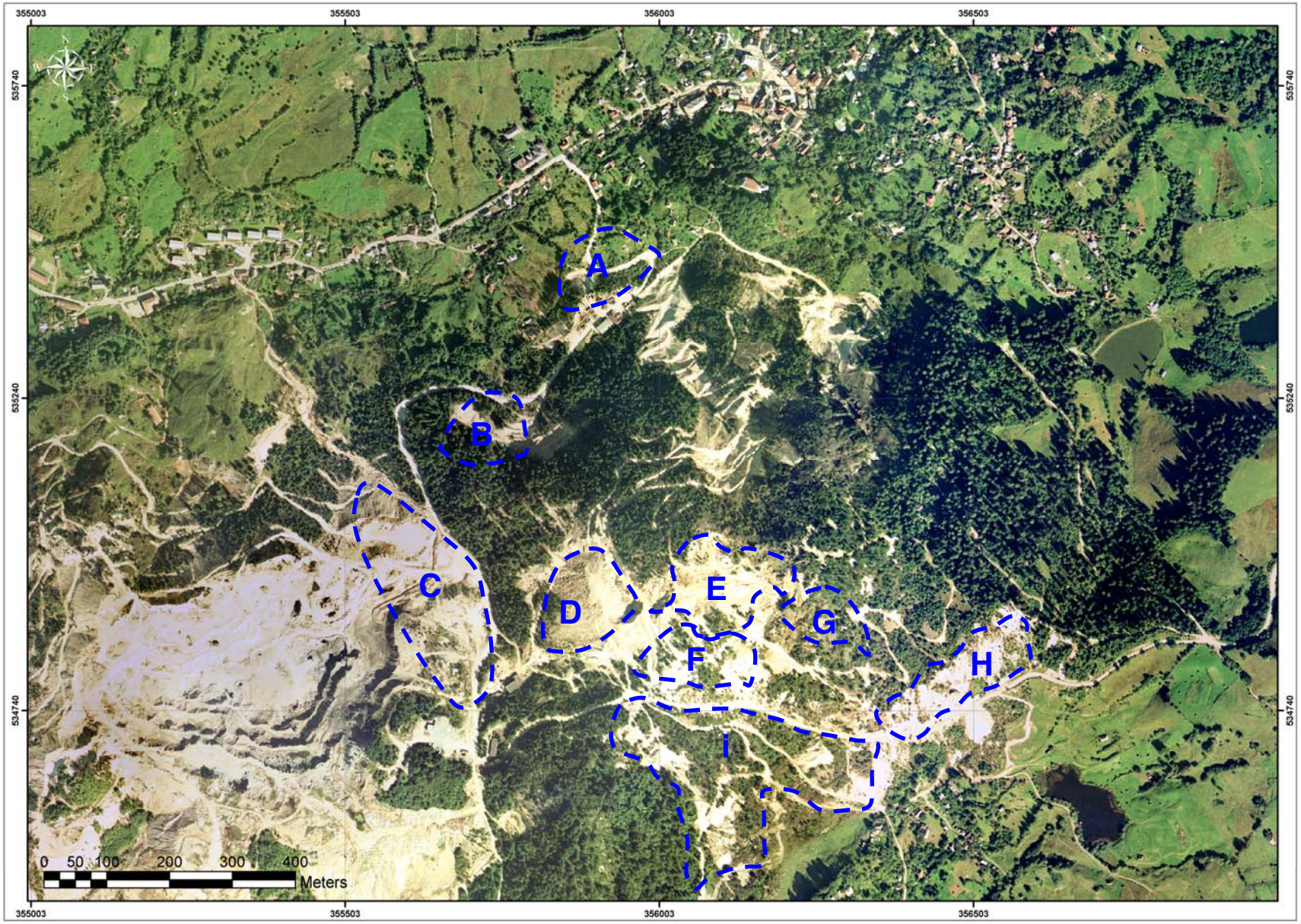
ROSIA MONTANA MINE
MINE MUSEUM
LAYOUT OF MODERN WORKINGS - LEVEL 932

FIGURE 6.1



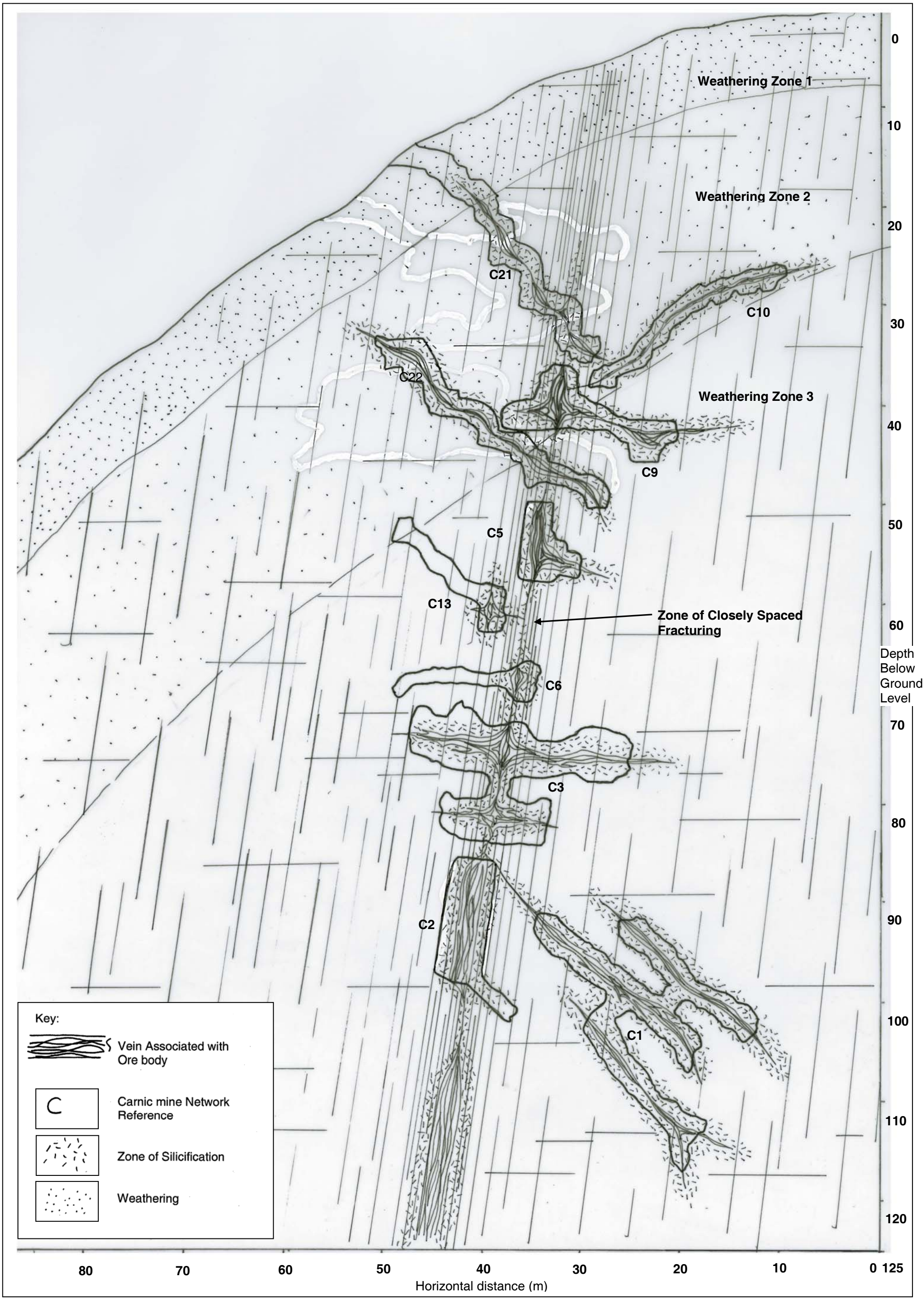
ROSIA MONTANA MINE
ACCESS ROADS AND CAR PARKS
AERIAL PLAN

FIGURE6.2



ROSIA MONTANA MINE
MINE MUSEUM
SLOPE STABILISATION PLAN

FIGURE 6.3



ROSIA MONTANA MINE
WEATHERING AND OVERBURDEN PROFILE

GEO-DESIGN

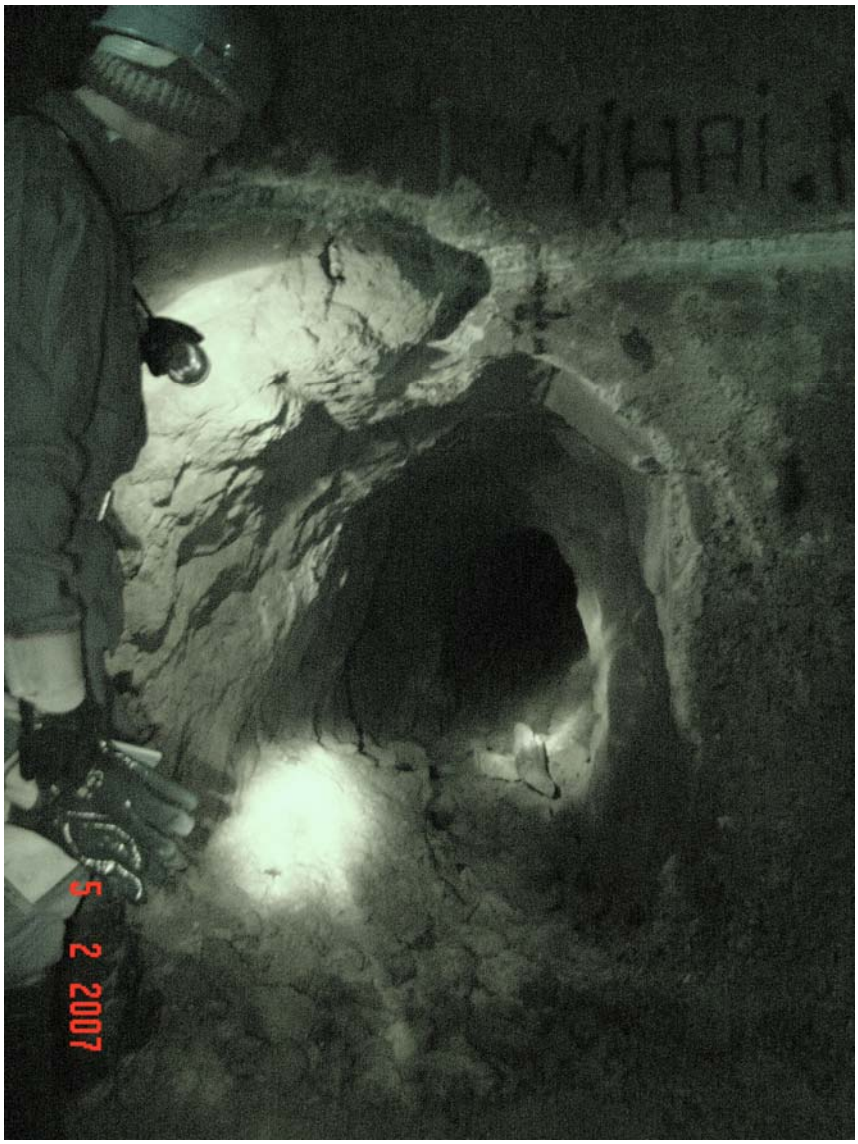
PLATES

ROSIA MONTANA - MINE MUSEUM STUDY
ENTRANCE P1 - LEVEL 958

NOTES :

1. Concrete block lining (there are several sections were the blocks have been removed).
2. Adit is partially filled with waste from excavation of roman workings, the waste needs to be removed to surface.

ROSIA MONTANA - MINE MUSEUM STUDY
ADIT LEADING FROM ENTRANCE P1 INTO 958 GALLERY



NOTES :

1. Example of narrow adit that requires widenning (for emergency exit).

ROSIA MONTANA - MINE MUSEUM STUDY
958 GALLERY LEADING TO CORANDA CORHURI - SIDE GALLERY

NOTES :

1. Area is located to the side of the Coranda. Intervening pillars left in place at the time of mining have since been removed leaving the opening unsupported.

ROSIA MONTANA - MINE MUSEUM STUDY
CORANDA CORHURI - MINED PILLAR

NOTES :

1. Iron staining and stalactites indicative of water ingress

ROSIA MONTANA - MINE MUSEUM STUDY
ROOM AND PILLAR LEVEL 958

NOTES :

1. Area of collapse at entrance to room and pillar workings. Instability caused by the presence of a throughgoing discontinuity that has caused failure in the pillar haunch and adjacent crown section.

ROSIA MONTANA - MINE MUSEUM STUDY
ROOM AND PILLAR LEVEL 958

NOTES :

1. Intact section of room and pillar with little evidence of overbreak.

ROSIA MONTANA - MINE MUSEUM STUDY
ROOM AND PILLAR LEVEL 958

NOTES :

1. Shafts (less than 2m diameter) link all room and pillar levels. Some shafts provide the only means of access to some room and pillar levels.

ROSIA MONTANA - MINE MUSEUM STUDY
SHAFT (LOOKING UP) FROM 958 LEVEL OF ROOM AND PILLAR TO LEVEL ABOVE

NOTES :

1. Complete replacement of all timber supports is required.

ROSIA MONTANA - MINE MUSEUM STUDY
MODERN GALLERY - ACCESS TO CARNIC 1 - ROTTING WOODEN PROPS

NOTES :

1. Recent partial collapse of the crown section of the adit (blocks with fresh surfaces strewn along invert of adit).

ROSIA MONTANA - MINE MUSEUM STUDY
MODERN GALLERY ACCESS TO CARNIC 1 - END OF WOODEN PROPPING

NOTES :

1. Residual pillar (undermined by subsequent levels (refer to following plate).

ROSIA MONTANA - MINE MUSEUM STUDY
CARNIC 1 - LARGE STOPE - ANCIENT GALLERY RE-WORKED BY MODERN

NOTES :

1. Lower mine levels, beneath the pillar are flooded.

ROSIA MONTANA - MINE MUSEUM STUDY
CARNIC 1 - VIEW OF PILLAR UNDERMINED BY SUBSEQUENT LEVELS

ROSIA MONTANA - MINE MUSEUM STUDY
MODERN GALLERY ACCESS TO CARNIC 3
WOODEN PROPPING PUT IN BY GABRIEL MINERS

NOTES :

1. Regular geometry in highly silicified rock.

ROSIA MONTANA - MINE MUSEUM STUDY
CARNIC 3 - INCLINED ROMAN GALLERY (G2) TOWARDS THE SURFACE

ROSIA MONTANA - MINE MUSEUM STUDY
CARNIC 3 - INCLINED ROMAN GALLERY (G2) TOWARDS THE SURFACE
MUD AND DEBRIS COMING IN FROM SURFACE COLLAPSE

NOTES :

1. High steeply inclined sidewalls - adversely affected by parallel jointing.

ROSIA MONTANA - MINE MUSEUM STUDY
CARNIC 3 - JUNCTION TO CARNIC 2 UPPER

NOTES :

1. Overhanging section on left hand side with parallel jointing and irregular load induced fracturing of the right hand side wall.

ROSIA MONTANA - MINE MUSEUM STUDY
LEVEL 932 CARNIC 2 (G100) - WOODEN PROPS SUPPORTING FAILING SIDE WALL

ROSIA MONTANA - MINE MUSEUM STUDY
GALLERY 31 - ROMAN INCLINED EXPLORATION GALLERY - LOWER SECTION FLOODED

ROSIA MONTANA - MINE MUSEUM STUDY
CARNIC 6 - FLOODED ROMAN GALLERY

NOTES :

1. Variably silicified weak rock mass, areas of significant overbreak and open jointing.

ROSIA MONTANA - MINE MUSEUM STUDY
CARNIC 13 - WOODEN PROPPING SUPPORTING THE ROOF

NOTES :

1. Very strong silicified rock mass.

ROSIA MONTANA - MINE MUSEUM STUDY
CARNIC 21/22 - ROMAN FIRE SETTINGS EXPLOITATION GALLERIES

ROSIA MONTANA - MINE MUSEUM STUDY
CARNIC 21/22 - EXAMPLE OF ROMAN FIRE SETTING EXPLOITATION

NOTES :

1. Poor mine entrance construction with ingress of surface water (frozen)

ROSIA MONTANA - MINE MUSEUM STUDY
ENTRANCE TO CARNIC 9

ROSIA MONTANA - MINE MUSEUM STUDY
CARNIC 9 MIDDLE LEVEL, MEDIEVAL WORKINGS, WOODEN PROPS

NOTES :

1. Areas of collapse retained by propping of right hand side of mine openning.

ROSIA MONTANA - MINE MUSEUM STUDY
CARNIC 9 - ACCESS TO CARNIC 10 - MODERN WORKINGS
WOODEN PROPPING INSTALLED BY GABRIEL MINERS

NOTES :

1. Wide inclined stope - no intervening pillars.

ROSIA MONTANA - MINE MUSEUM STUDY
CARNIC 10 - INCLINED STOPE

NOTES :

1. All side walls to original Roman galleries have been completely or partially removed, leaving large span openings unsupported.

ROSIA MONTANA - MINE MUSEUM STUDY
CARNIC 10 - PARALLEL ROMAN GALLERIES - RE-WORKED BY MODERN

APPENDIX A

MINE MUSEUM - SUMMARY OF REQUIRED WORKS

Tour Stop No.	Description	Required Work	Reference Tables and Figures

1	Main entrance 958mOD (Portal 1)	• 2000m^2 platform at the entrance to accommodate:
		  - Car park
		  - Visitor Centre
		• Visitor Centre (could also be located in the village) containing the following:
		  - Toilets
		  - Ticket Office
		  - First Aid Room
		  - Tourist Information
		  - Restaurant/Café
		  - Changing Rooms
		• Infrastructure:
		  - Electricity
		  - Water
		  - Drainage (Fresh and Foul)
		  - Phone Lines
		• Re-surfacing and consolidating of the access road from Rosia town square.
		• Stabilisation of the Western side of the Carnic open pit.
		• Stabilisation and consolidation of the Piatra Despicata collapsed shaft.
		• Access roads linking to other portals and to the main ring road.
			• Table 6.1
			• Table 6.2
			• Table 6.3
			• Figure 1.1
			• Figure 1.2
			• Figure 6.1
			• Figure 6.2

2	Travelling on the Electric Train to Coranda Corhuri	• Widening and support of access adit from Portal 1 to Coranda Corhuri • Lighting and Ventilation of access adit • Installation of the electric railway • Isolating and backfilling adjacent adits and shafts • Installation of compressor into the old compressor room • First aid room and toilets at the end of the access adit	• Table 6.5.1 • Table 6.6 • Figure 1.1 • Figure 5.2

Tour Stop No.	Description	Required Work	Reference Tables and Figures
3	Coranda Corhuri	• Train stop and platform • Support and widening of access adits around the Coranda • 2 observation platforms (each 20m^2) • Support and consolidation of the Coranda • Lighting and ventilation of the Coranda • Information boards detailing the Coranda and the 1961 mining accident • Backfilling and consolidating surrounding mine workings.	• Table 6.9 • Table 6.5.1 • Table 6.7 • Figure 1.1 • Figure 5.2
4	Corhuri Shaft	• Stabilisation of the shaft entrance • Stabilisation and widening of the shaft from 958mOD down to 853mOD • Stabilise and widen exit adit from base of the shaft to Portal 4 • Stabilise and support Portal 4 • Install infrastructure at Portal 4, including: - 50m^2 Platform - Access Roads - Mine Rescue Unit with building - Electricity, Phone line, Water • Lighting and ventilation of the shaft and exit adit	• Table 6.3 • Table 6.9 • Table 6.5.2 • Figure 1.1 • Figure 5.2 • Figure 6.1 • Figure 6.2
5	Corhuri Room and Pillar Workings	• Backfill and consolidate adjacent mine workings • Backfill levels above and below the 958mOD level • Stabilise 958mOD level • Remove any tailings from 958mOD level • Lighting and ventilation • Widen and support adit leading to Portal 3 (emergency access/exit) • Install infrastructure at Portal 3, including: - 50m^2 Platform - Access Roads - Mine Rescue Unit with building - Electricity, Phone line, Water	• Table 6.3 • Table 6.5.2 • Table 6.6 • Table 6.8.1 • Table 6.8.2 • Table 6.10 • Figure 1.1 • Figure 5.2 • Figure 6.1 • Figure 6.2

Tour Stop No.	Description	Required Work	Reference Tables and Figures
6	Return trip from Corhuri to Carnic 1	• Passenger platform at the start of access adit towards Carnic 1 • Widen and stabilise adit from train platform to Carnic 1 • Lighting and ventilation	• Table 6.5.2 • Figure 1.1 • Figure 1.2 • Figure 5.2
7	Carnic 1 network	• Restoration and support of Carnic 1 network • Provision of permanent walkways (and handrails) within Carnic 1 • Provision of steps between levels in Carnic 1 • Lighting and ventilation • De-watering in some of the lower areas	• Table 4.1 • Table 4.2 • Table 4.3 • Table 4.4 • Table 6.5.2 • Table 6.6 • Table 6.11 • Table 6.12 • Figure 1.1 • Figure 1.2 • Figure 5.2 • Figure 6.3
8	Travelling from Carnic 1 to Carnic 3	• Widen and stabilise adit from Carnic 1 to Carnic 2 • Widen and stabilise emergency access adit to surface • Install infrastructure at Portal 5, including: - 200m^2 Platform - Access Roads - Mine Rescue Unit with building - Electricity, Phone line, Water - Stabilise slopes • Isolate and backfill adjacent mine workings • Lighting and ventilation • Dewatering	• Table 6.1 • Table 6.2 • Table 6.3 • Table 6.5.2 • Table 6.6 • Figure 1.1 • Figure 1.2 • Figure 5.2 • Figure 6.1 • Figure 6.2

Tour Stop No.	Description	Required Work	Reference Tables and Figures
9	Carnic 3 network	• Restoration and support of the Carnic 3 network • Remove backfill and mine tailings • Isolate and backfill/consolidate the centre of the Carnic 3 network • Consolidate remaining backfill • Provision of permanent walkways, stairs and handrails • Lighting and ventilation • Dewatering	• Table 4.1 • Table 4.2 • Table 4.3 • Table 4.4 • Table 6.5.2 • Table 6.6 • Table 6.11 • Table 6.12 • Figure 1.1 • Figure 1.2 • Figure 5.2 • Figure 6.6
10	Carnic 2 network	• Restoration and support of the Carnic 3 network • Remove backfill and mine tailings • Isolate and backfill/consolidate the centre of the Carnic 3 network • Consolidate remaining backfill • Provision of permanent walkways, stairs and handrails • Lighting and ventilation • Dewatering	• Table 4.1 • Table 4.2 • Table 4.3 • Table 4.4 • Table 6.5.2 • Table 6.6 • Table 6.11 • Table 6.12 • Figure 1.1 • Figure 1.2 • Figure 5.2 • Figure 6.3

Tour Stop No.	Description	Required Work	Reference Tables and Figures
11	932mOD Level adit	• Widen and stabilise the adit • Isolate and backfill/consolidate adjacent mine workings • Lighting and Ventilation • Dewatering	• Table 6.5.3 • Table 6.6 • Figure 1.1 • Figure 1.2 • Figure 5.1
12	Carnic 5 network	• Restoration and support of the Carnic 5 network • Remove backfill and mine tailings • Isolate and backfill/consolidate the centre of the Carnic 5 network • Consolidate remaining backfill • Provision of permanent walkways, stairs and handrails • Lighting and ventilation • Dewatering	• Table 4.1 • Table 4.2 • Table 4.3 • Table 4.4 • Table 6.5.3 • Table 6.6 • Table 6.11 • Table 6.12 • Figure 1.1 • Figure 1.2 • Figure 5.2 • Figure 6.3
13	Adit from Carnic 5 to Carnic 6	• Widen and stabilise the adit • Isolate and backfill/consolidate adjacent mine workings • Lighting and Ventilation • Dewatering	• Table 6.5.3 • Table 6.6 • Figure 1.1 • Figure 1.2 • Figure 5.1

Tour Stop No.	Description	Required Work	Reference Tables and Figures
14	Carnic 6 network	• Restoration and support of the Carnic 6 network • Remove backfill and mine tailings • Isolate and backfill/consolidate the centre of the Carnic 6 network • Consolidate remaining backfill • Provision of permanent walkways, stairs and handrails • Lighting and ventilation • Dewatering • Provide waiting area for Shaft 1	• Table 4.1 • Table 4.2 • Table 4.3 • Table 4.4 • Table 6.5.3 • Table 6.6 • Table 6.11 • Table 6.12 • Figure 1.1 • Figure 1.2 • Figure 5.2 • Figure 6.3
15	Shaft 1 (932mOD to 960mOD)	• Excavation of 4m diameter shaft • Lighting and ventilation of shaft and immediate areas • Installation of infrastructure within the shaft. • Installation of necessary infrastructure at 960mOD exit of shaft	• Table 6.4 • Table 6.5.3 • Figure 1.1 • Figure 1.2 • Figure 5.1
16	Adit from Shaft 1 to Carnic 13 network	• Advance adit through unstable rock and existing unstable workings • Stabilise new adit • Lighting and ventilation • Create waiting area at the top of Shaft 1 • Toilets and first aid room at the top of the shaft	• Table 6.5.3 • Table 6.6 • Figure 1.1 • Figure 1.2

Tour Stop No.	Description	Required Work	Reference Tables and Figures
17	Carnic 13 network	• Restoration and support of the Carnic 13 network • Remove backfill and mine tailings • Provision of permanent walkways, stairs and handrails • Lighting and ventilation • Dewatering • Stabilise and widen emergency access shaft leading to Portal 7 • Install infrastructure at Portal 7, including: - $100m^2$ Platform - Access Roads - Mine Rescue Unit with building - Electricity, Phone line, Water - Stabilise slopes	• Table 4.1 • Table 4.2 • Table 4.3 • Table 4.4 • Table 6.1 • Table 6.2 • Table 6.3 • Table 6.5.4 • Table 6.6 • Table 6.11 • Table 6.12 • Figure 1.1 • Figure 1.2 • Figure 6.1 • Figure 6.2 • Figure 6.3
18	Adit from Carnic 13 to Carnic 21 and 22	• Restoration and support of the Carnic 13 network • Remove backfill and mine tailings • Provision of permanent walkways, stairs and handrails • Lighting and ventilation	• Table 6.5.4 • Table 6.6 • Figure 1.1 • Figure 1.2

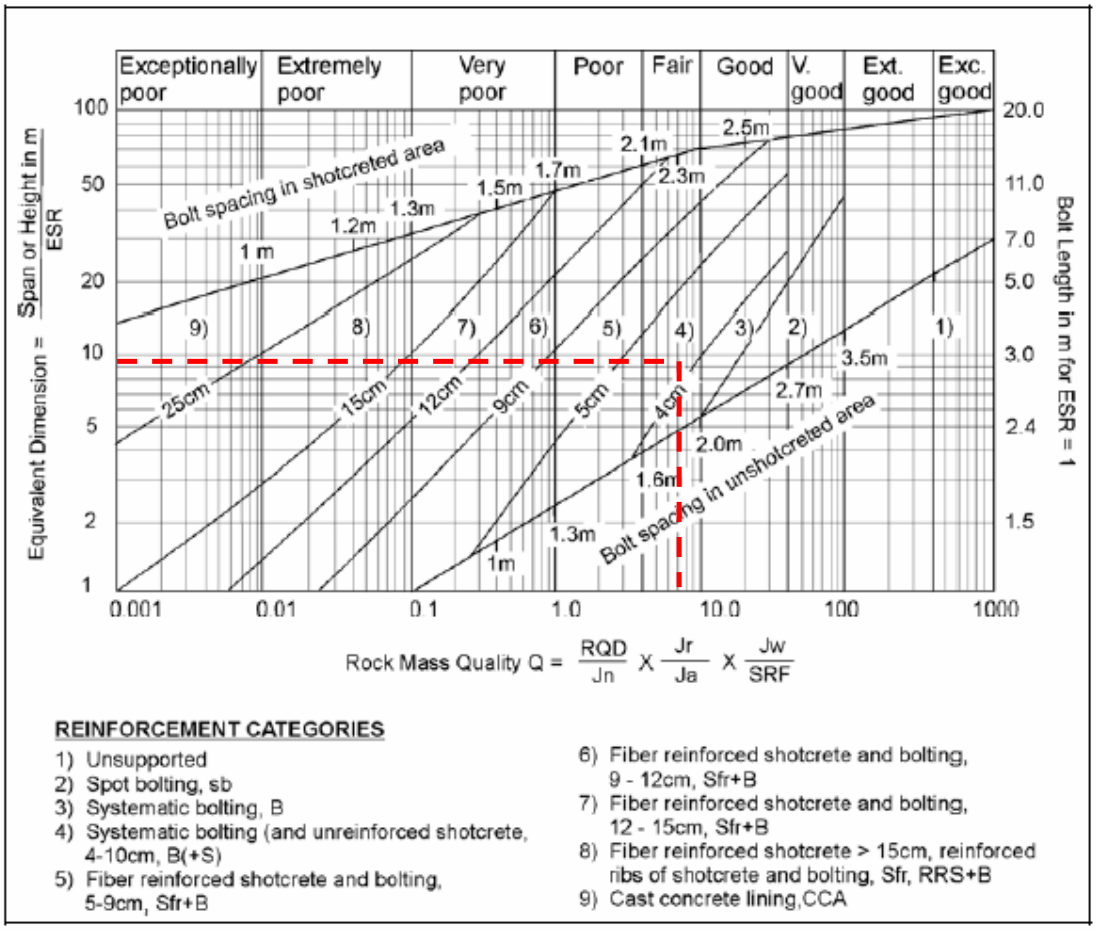
Tour Stop No.	Description	Required Work	Reference Tables and Figures
19	Carnic 21 and 22 networks	• Restoration and support of the Carnic 21 and 22 network • Remove backfill and mine tailings • Isolate and backfill/consolidate the centre of the Carnic 21 and 22 network • Consolidate remaining backfill • Provision of permanent walkways, stairs and handrails • Lighting and ventilation • Dewatering • Provide waiting area for Shaft 2	• Table 4.1 • Table 4.2 • Table 4.3 • Table 4.4 • Table 6.5.4 • Table 6.6 • Table 6.11 • Table 6.12 • Figure 1.1 • Figure 1.2 • Figure 6.3
20	Shaft 2 (Exit from Carnic 21 and 22 to surface)	• Excavate and support shaft (40m long) • Provide surface infrastructure for shaft: - $100m^2$ Platform - Access Roads - Mine Rescue Unit with building - Electricity, Phone line, Water - Stabilise slopes - Toilets and first aid room - Refreshments • Light and ventilate shaft and waiting area • Provide transport or footpath towards Portal 8 into Carnic 9 and 10 networks	• Table 6.1 • Table 6.2 • Table 6.4 • Figure 1.1 • Figure 1.2 • Figure 6.1 • Figure 6.2

Tour Stop No.	Description	Required Work	Reference Tables and Figures
21	Portal 8 to Carnic 9 network	• Widening and support of Portal 8 • Widening and support of the adit • Access road and waiting platform at Portal 8 • Lighting • Stabilise slopes around Portal 8	• Table 6.1 • Table 6.2 • Table 6.3 • Table 6.5.4 • Figure 1.1 • Figure 1.2 • Figure 6.1 • Figure 6.2
22	Carnic 9 network	• Support and consolidation of existing mine workings • Provision of permanent walkways • Backfilling and consolidation of adjacent mine workings • Lighting and ventilation • Removal of backfill • Consolidation of remaining backfill	• Table 4.1 • Table 4.2 • Table 4.3 • Table 4.4 • Table 6.5.4 • Table 6.6 • Table 6.11 • Table 6.12
23	Adit from Carnic 9 to Carnic 10 network	• Widen and stabilise the adit • Lighting and ventilation • Backfill and isolate adjacent mine workings • Dewatering • Consolidate or remove existing backfill	• Table 6.5.4 • Table 6.6 • Figure 1.1 • Figure 1.2

Tour Stop No.	Description	Required Work	Reference Tables and Figures
24	Carnic 10 network	• Support and consolidation of existing mine workings • Provision of permanent walkways • Backfilling and consolidation of adjacent mine workings • Lighting and ventilation • Removal of backfill • Consolidation of remaining backfill • Provide waiting area at base of Shaft 4	• Table 4.1 • Table 4.2 • Table 4.3 • Table 4.4 • Table 6.4 • Table 6.11 • Table 6.12 • Figure 1.1 • Figure 1.2 • Figure 6.3
25	Shaft 4 (Exit from Carnic 10 to surface)	• Excavate and support shaft • Provide surface infrastructure for shaft: - Surface Platform - Access Roads - Mine Rescue Unit with building - Electricity, Phone line, Water - Stabilise slopes - Toilets and first aid room - Refreshments - Transport back to car park or to Rosia town square • Light and ventilate shaft and waiting area	• Table 6.1 • Table 6.2 • Table 6.3 • Table 6.4 • Figure 1.1 • Figure 1.2 • Figure 6.1 • Figure 6.2

APPENDIX B

ESTIMATION OF SUPPORT REQUIREMENTS - ROMAN WORKINGS



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting (and unreinforced shotcrete, 4-10cm, B(+S)
5) Fiber reinforced shotcrete and bolting, 5-9cm, Sfr+B
6) Fiber reinforced shotcrete and bolting, 9 - 12cm, Sfr+B
7) Fiber reinforced shotcrete and bolting, 12 - 15cm, Sfr+B
8) Fiber reinforced shotcrete > 15cm, reinforced ribs of shotcrete and bolting, Sfr, RRS+B
9) Cast concrete lining,CCA

KEY ATTRIBUTES	
SH / SV	SH
Span (m)	7
Height (m)	(1.5m)
Rock Mass Class	CR3
Q typical	6.0
Support Category	4

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	2.3m
Bolt length (m)	3.5
Mesh	Double Twist Maccaferri mesh (30%)
Shotcrete	-
Area (m^2)	156
Number of bolts	34

PILLAR RECONSTRUCTION	
Height (m)	-
Width (m)	-
Length (m)	-
No. of Pillars	-
Volume (m^3)	-

GROUTING ADJACENT LOOSE BACKFILL	-

VOLUME OF TEMPORARY BACKFILL	-

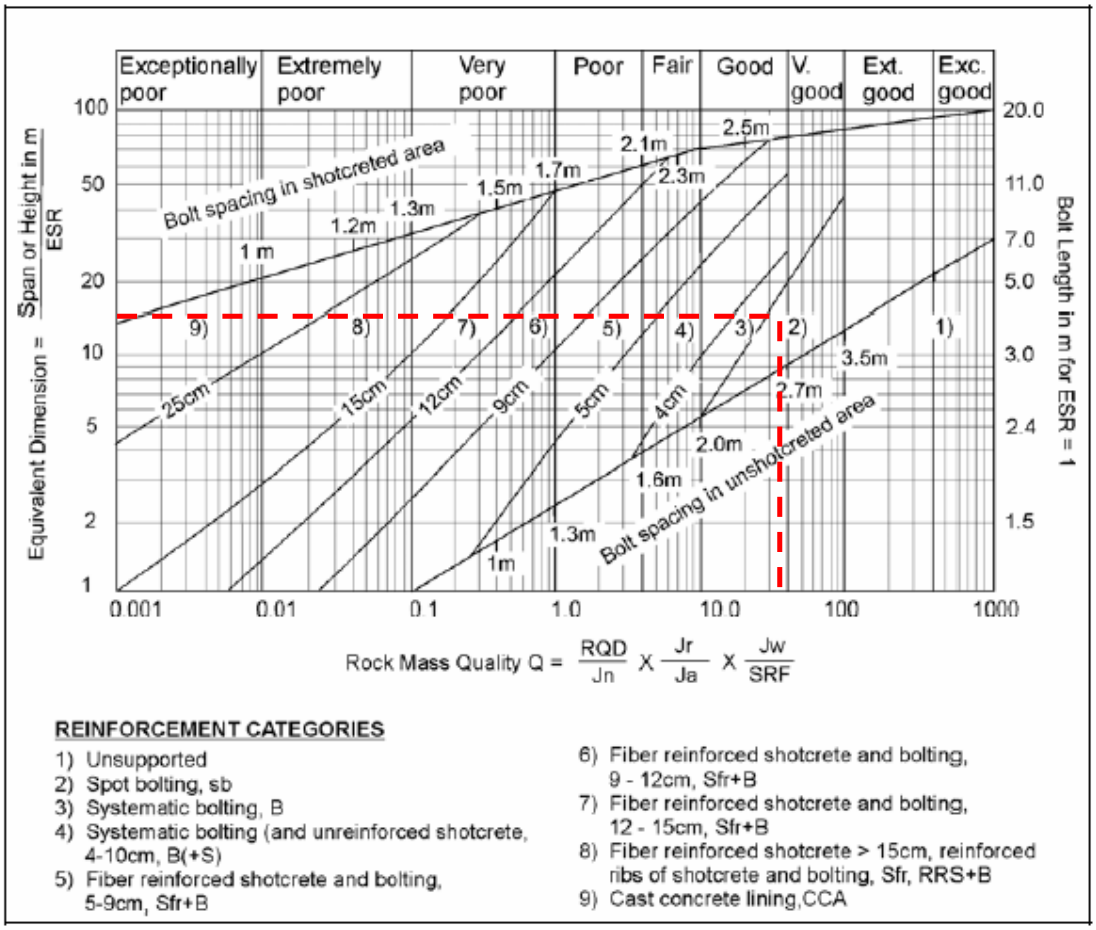
VOLUME OF MATERIAL TO BE EXCAVATED	-

DEWATERING REQUIRED	Yes – D10

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART - CARNIC 1 LOWER



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting (and unreinforced shotcrete, 4-10cm, B(+S)
5) Fiber reinforced shotcrete and bolting, 5-9cm, Sfr+B
6) Fiber reinforced shotcrete and bolting, 9 - 12cm, Sfr+B
7) Fiber reinforced shotcrete and bolting, 12 - 15cm, Sfr+B
8) Fiber reinforced shotcrete > 15cm, reinforced ribs of shotcrete and bolting, Sfr, RRS+B
9) Cast concrete lining,CCA

KEY ATTRIBUTES	
SH / SV	SH
Span (m)	12
Height (m)	(3m)
Rock Mass Class	CR2
Q typical	37.5
Support Category	4

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	2.8
Bolt length (m)	4.5
Mesh	Double Twist Maccaferri mesh (30%)
Shotcrete	-
Area (m^2)	152
Number of bolts	27

PILLAR RECONSTRUCTION	
Height (m)	3
Width (m)	2
Length (m)	2
No. of Pillars	3
Volume (m^3)	36

GROUTING ADJACENT LOOSE BACKFILL	-

VOLUME OF TEMPORARY BACKFILL	560m^3

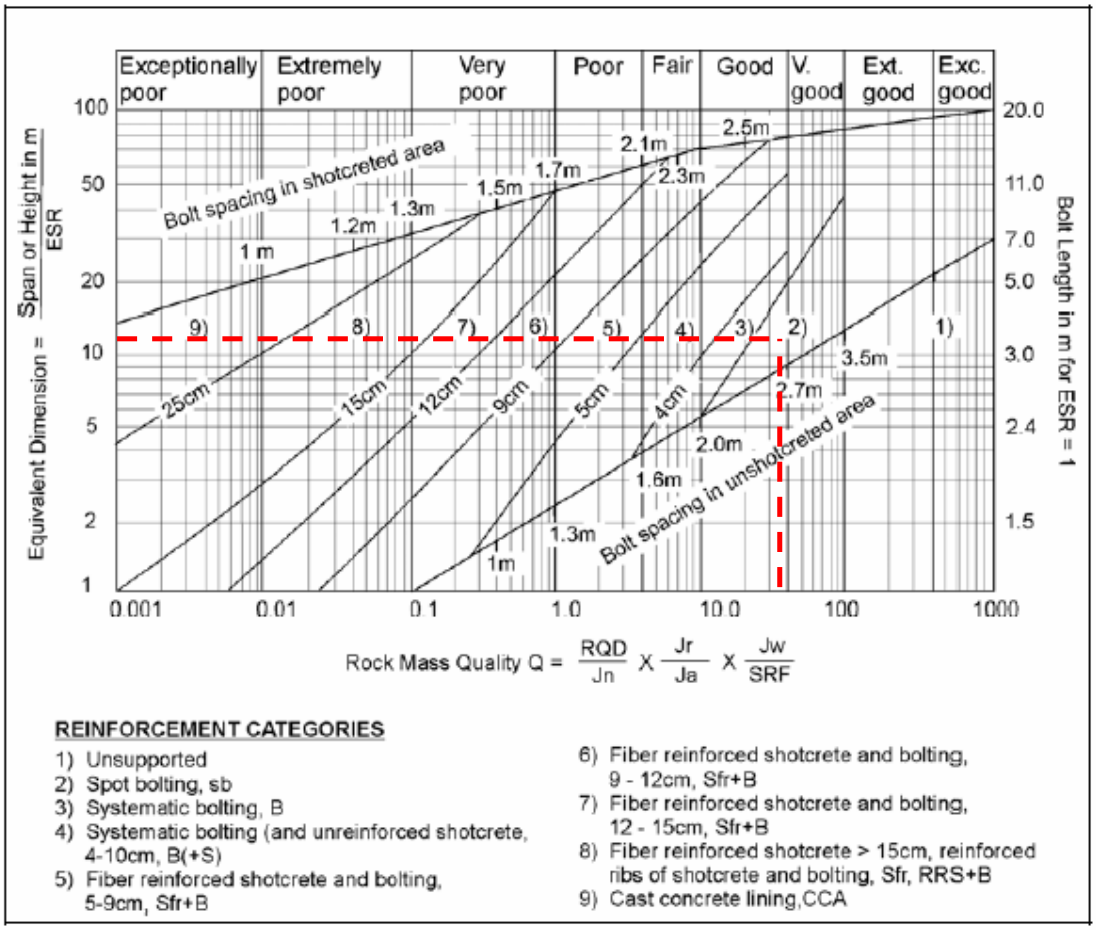
VOLUME OF MATERIAL TO BE EXCAVATED	216m^3

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART - CARNIC 1 MIDDLE



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting (and unreinforced shotcrete, 4-10cm, B(+S)
5) Fiber reinforced shotcrete and bolting, 5-9cm, Sfr+B
6) Fiber reinforced shotcrete and bolting, 9 - 12cm, Sfr+B
7) Fiber reinforced shotcrete and bolting, 12 - 15cm, Sfr+B
8) Fiber reinforced shotcrete > 15cm, reinforced ribs of shotcrete and bolting, Sfr, RRS+B
9) Cast concrete lining,CCA

KEY ATTRIBUTES	
SH / SV	SH
Span (m)	10
Height (m)	3 - 6
Rock Mass Class	CR2
Q typical	37.5
Support Category	3

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	2.8
Bolt length (m)	4.5
Mesh	Double Twist Maccaferri mesh (30%)
Shotcrete	-
Area (m^2)	274
Number of bolts	49

PILLAR RECONSTRUCTION	
Height (m)	6m
Width (m)	2
Length (m)	2
No. of Pillars	3
Volume (m^3)	72

GROUTING ADJACENT LOOSE BACKFILL	-

VOLUME OF TEMPORARY BACKFILL	450m^3

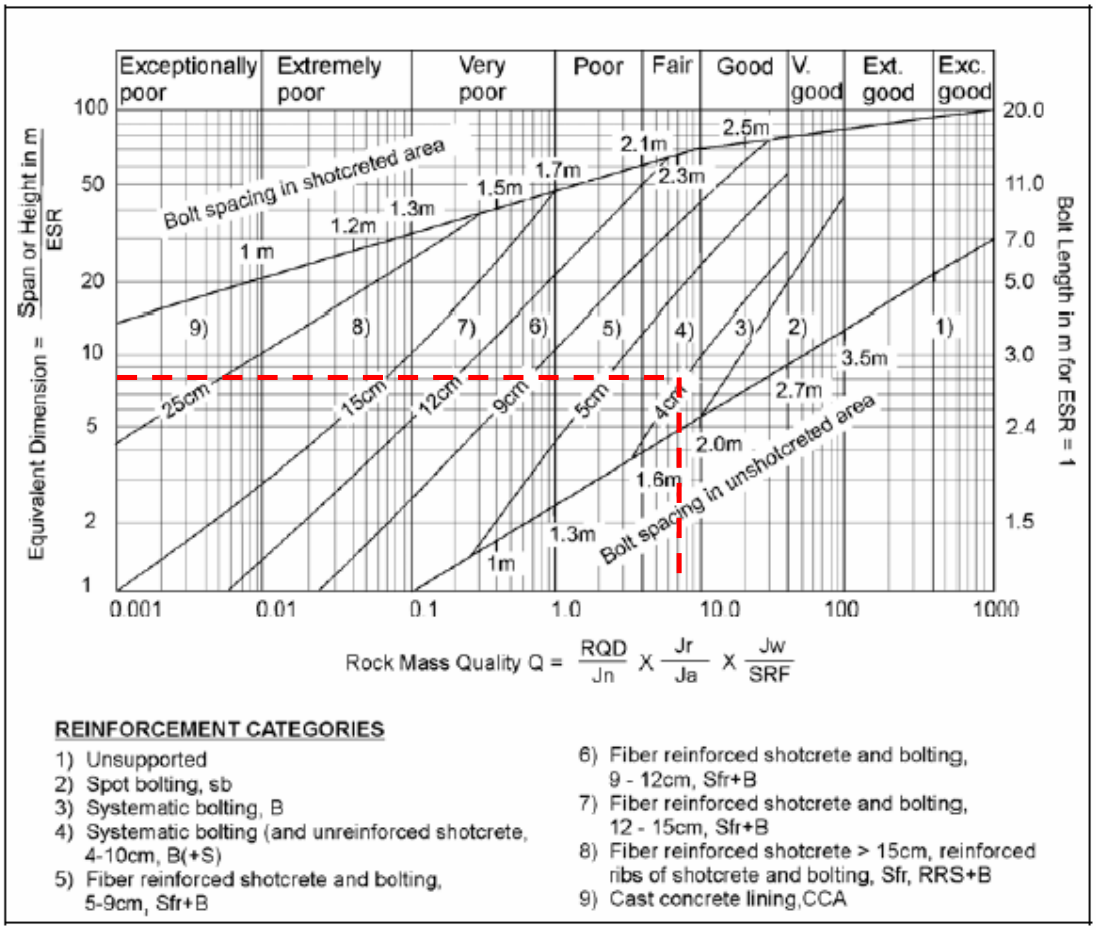
VOLUME OF MATERIAL TO BE EXCAVATED	80m^3

DEWATERING REQUIRED	Yes – D17

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART - CARNIC 1 UPPER



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting (and unreinforced shotcrete, 4-10cm, B(+S)
5) Fiber reinforced shotcrete and bolting, 5-9cm, Sfr+B
6) Fiber reinforced shotcrete and bolting, 9 - 12cm, Sfr+B
7) Fiber reinforced shotcrete and bolting, 12 - 15cm, Sfr+B
8) Fiber reinforced shotcrete > 15cm, reinforced ribs of shotcrete and bolting, Sfr, RRS+B
9) Cast concrete lining,CCA

KEY ATTRIBUTES	
SH / SV	SV (Adit)
Span (m)	(2)
Height (m)	6
Rock Mass Class	SW2
Q typical	8.3
Support Category	4

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	2.3
Bolt length (m)	3.5
Mesh	Double Twist Maccaferri mesh
Shotcrete	-
Area (m^2)	165
Number of bolts	36

PILLAR RECONSTRUCTION	
Height (m)	5
Width (m)	1
Length (m)	1
No. of Pillars	1
Volume (m^3)	5

GROUTING ADJACENT LOOSE BACKFILL	-

VOLUME OF TEMPORARY BACKFILL	500m^3

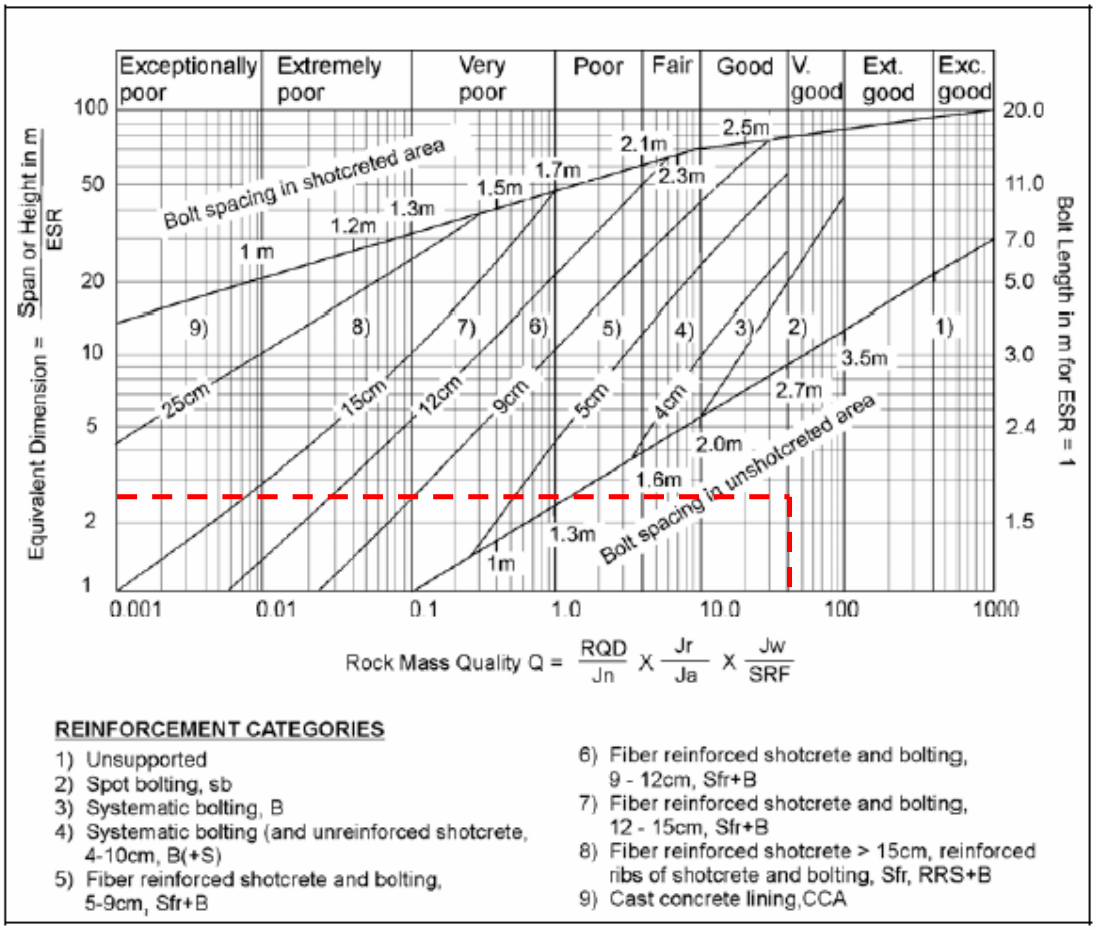
VOLUME OF MATERIAL TO BE EXCAVATED	-

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – G101 & D17



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting (and unreinforced shotcrete, 4-10cm, B(+S)
5) Fiber reinforced shotcrete and bolting, 5-9cm, Sfr+B
6) Fiber reinforced shotcrete and bolting, 9 - 12cm, Sfr+B
7) Fiber reinforced shotcrete and bolting, 12 - 15cm, Sfr+B
8) Fiber reinforced shotcrete > 15cm, reinforced ribs of shotcrete and bolting, Sfr, RRS+B
9) Cast concrete lining,CCA

KEY ATTRIBUTES	
SH / SV	SH (Adit)
Span (m)	2
Height (m)	(2)
Rock Mass Class	CR2
Q typical	37.5
Support Category	1

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	-
Bolt length (m)	-
Mesh	
Shotcrete	-
Area (m^2)	-
Number of bolts	-

PILLAR RECONSTRUCTION	
Height (m)	-
Width (m)	-
Length (m)	-
No. of Pillars	-
Volume (m^3)	-

GROUTING ADJACENT LOOSE BACKFILL	-

VOLUME OF TEMPORARY BACKFILL	-

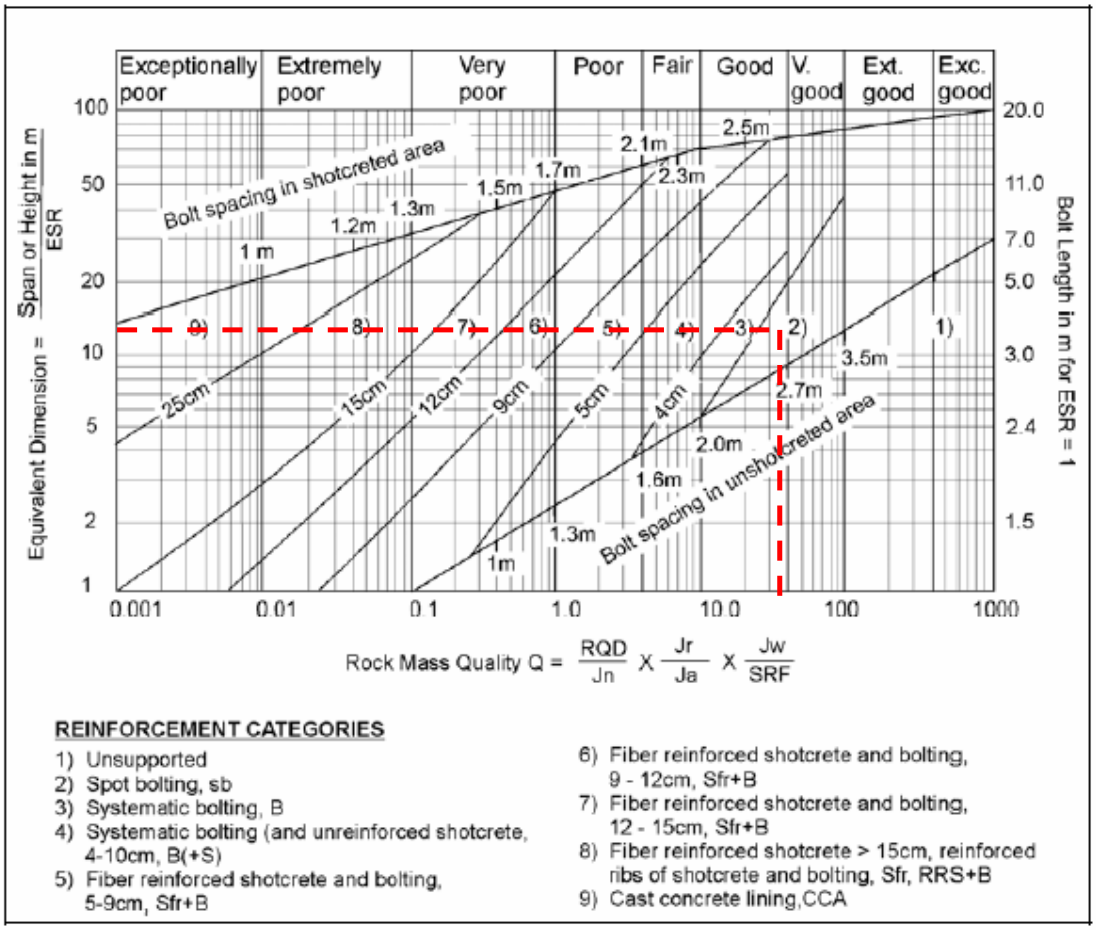
VOLUME OF MATERIAL TO BE EXCAVATED	-

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART - CARNIC 2 LOWER



KEY ATTRIBUTES	
SH / SV	SH
Span (m)	10
Height (m)	(2-3)
Rock Mass Class	CR2
Q typical	37.5
Support Category	3

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	2.8
Bolt length (m)	4.0
Mesh	Double Twist Maccaferri mesh (30%)
Shotcrete	-
Area (m^2)	125
Number of bolts	22

PILLAR RECONSTRUCTION	
Height (m)	-
Width (m)	-
Length (m)	-
No. of Pillars	-
Volume (m^3)	-

GROUTING ADJACENT LOOSE BACKFILL	-

VOLUME OF TEMPORARY BACKFILL	-

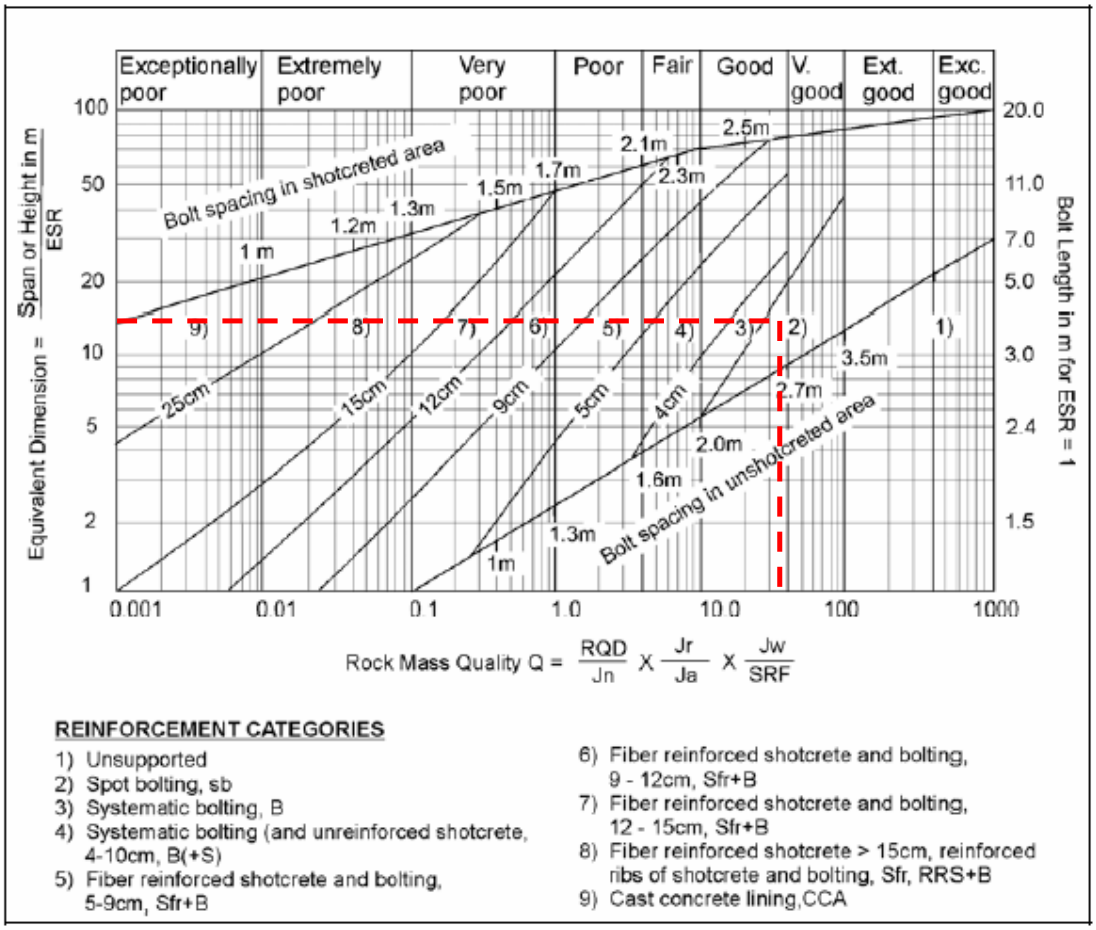
VOLUME OF MATERIAL TO BE EXCAVATED	34.5m^3

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART - CARNIC 2 MIDDLE



KEY ATTRIBUTES	
SH / SV	SH (Adit)
Span (m)	10
Height (m)	(2-3)
Rock Mass Class	CR2
Q typical	37.5
Support Category	1

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	-
Bolt length (m)	-
Mesh	-
Shotcrete	-
Area (m^2)	-
Number of bolts	-

PILLAR RECONSTRUCTION	
Height (m)	-
Width (m)	-
Length (m)	-
No. of Pillars	
Volume (m^3)	-

GROUTING ADJACENT LOOSE BACKFILL	-

VOLUME OF TEMPORARY BACKFILL	-

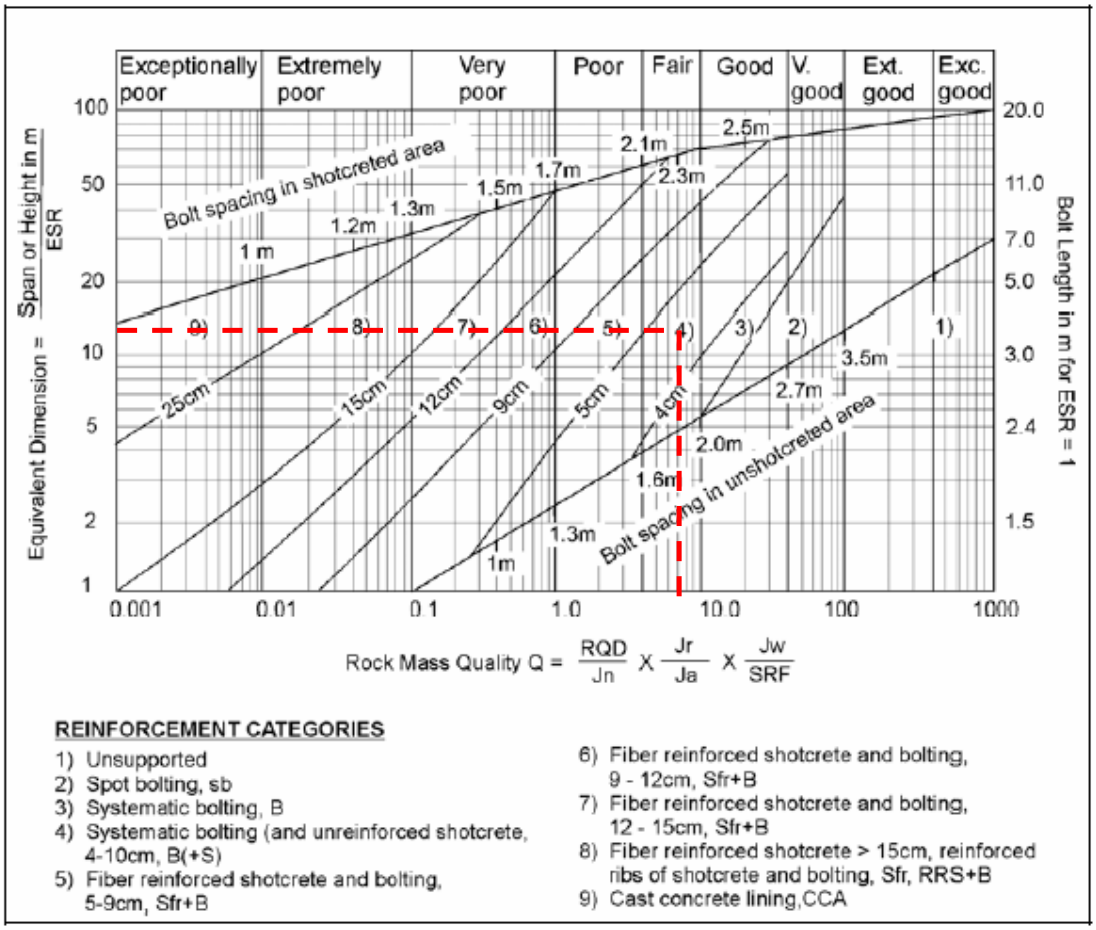
VOLUME OF MATERIAL TO BE EXCAVATED	-

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART - CARNIC 2 UPPER



KEY ATTRIBUTES	
SH / SV	SV (Cor.)
Span (m)	2.5
Height (m)	9
Rock Mass Class	SW2
Q typical	8.3
Support Category	4

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	2.4
Bolt length (m)	4.0
Mesh	Double Twist Maccaferri mesh (50%)
Shotcrete	-
Area (m^2)	126
Number of bolts	26

PILLAR RECONSTRUCTION	
Height (m)	-
Width (m)	-
Length (m)	-
No. of Pillars	-
Volume (m^3)	-

GROUTING ADJACENT LOOSE BACKFILL	-

VOLUME OF TEMPORARY BACKFILL	52.5m^3

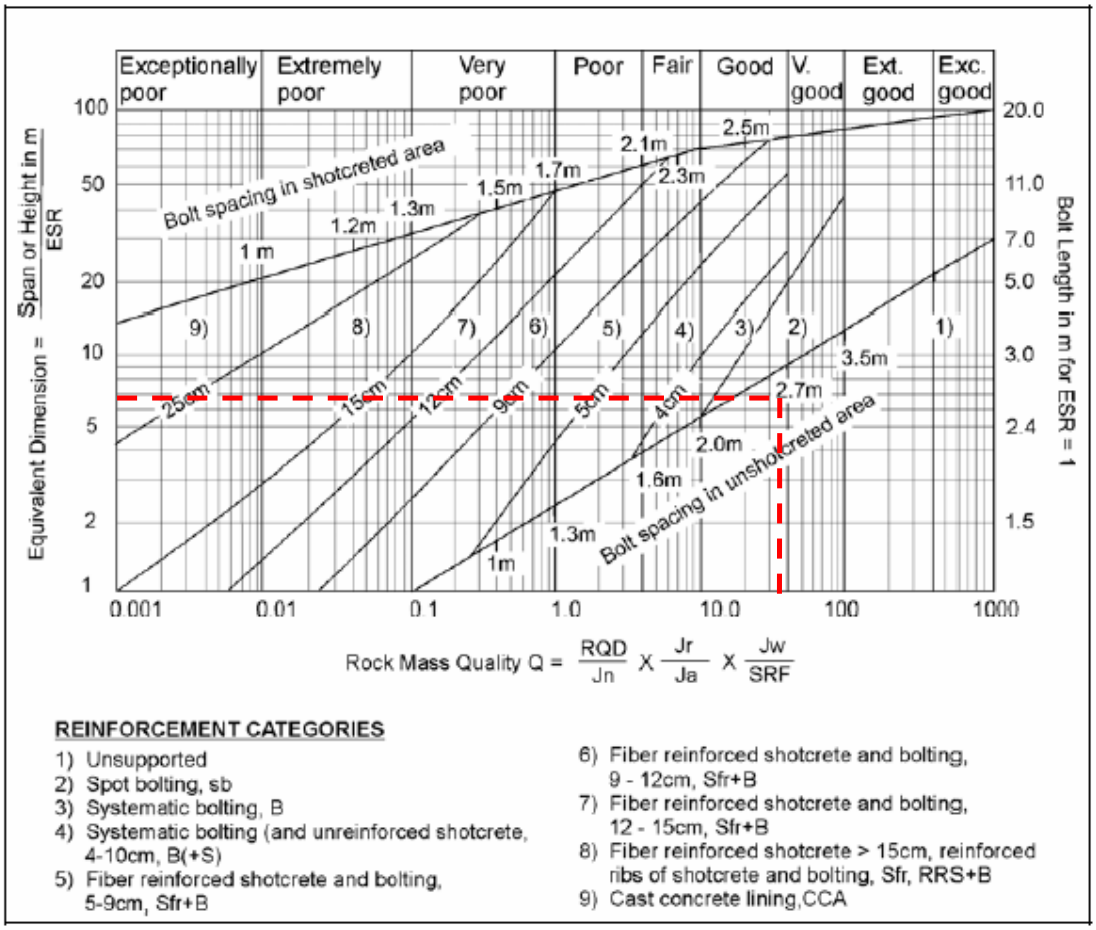
VOLUME OF MATERIAL TO BE EXCAVATED	280m^3

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART - CARNIC 2 CORANDA (SIDEWALL)



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting (and unreinforced shotcrete, 4-10cm, B(+S)
5) Fiber reinforced shotcrete and bolting, 5-9cm, Sfr+B
6) Fiber reinforced shotcrete and bolting, 9 - 12cm, Sfr+B
7) Fiber reinforced shotcrete and bolting, 12 - 15cm, Sfr+B
8) Fiber reinforced shotcrete > 15cm, reinforced ribs of shotcrete and bolting, Sfr, RRS+B
9) Cast concrete lining,CCA

KEY ATTRIBUTES	
SH / SV	SH (Cor.)
Span (m)	5
Height (m)	2.25
Rock Mass Class	CR2
Q typical	37.5
Support Category	3

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	2.8
Bolt length (m)	3.5
Mesh	Double Twist Maccaferri mesh (100%)
Shotcrete	-
Area (m^2)	70
Number of bolts	13

PILLAR RECONSTRUCTION	
Height (m)	-
Width (m)	-
Length (m)	-
No. of Pillars	-
Volume (m^3)	-

GROUTING ADJACENT LOOSE BACKFILL	-

VOLUME OF TEMPORARY BACKFILL	52.5m^3

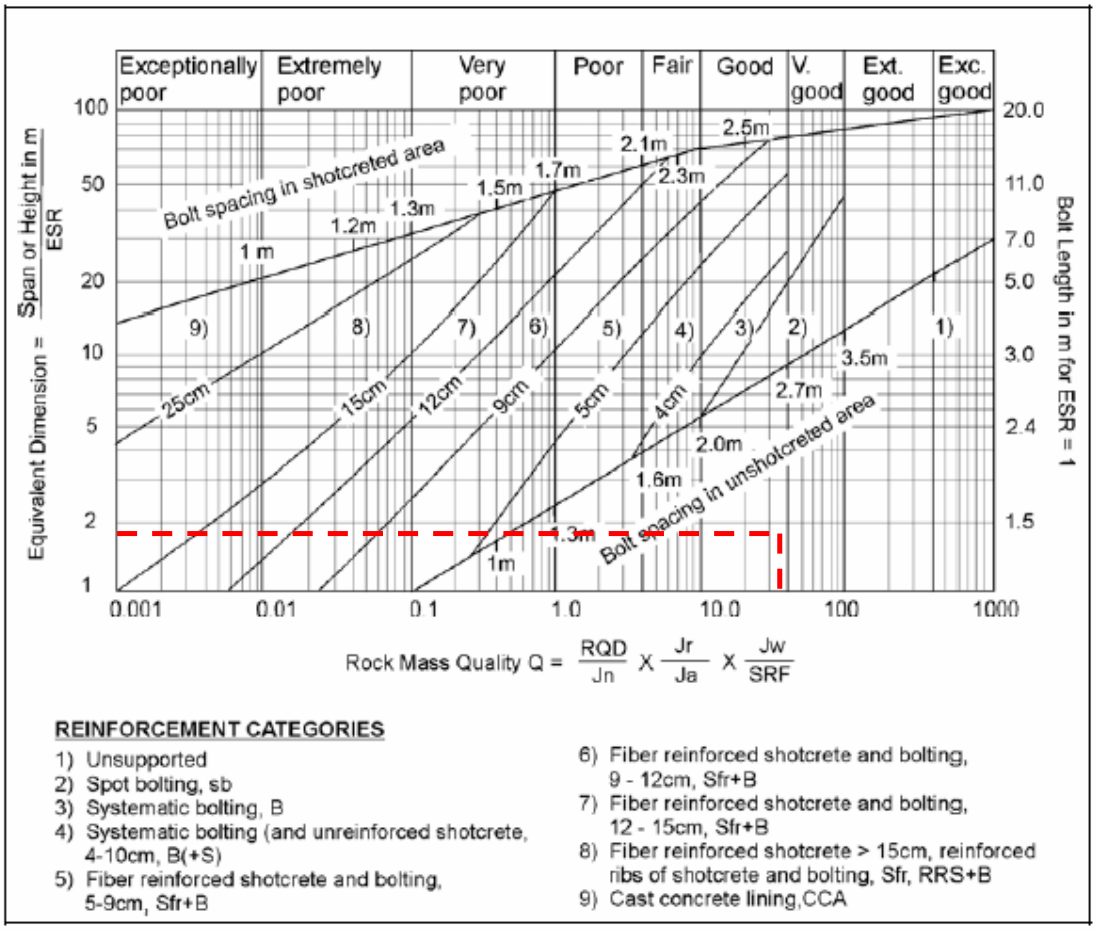
VOLUME OF MATERIAL TO BE EXCAVATED	34.5m^3

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART - CARNIC 2 CORANDA (CROWN)



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting (and unreinforced shotcrete, 4-10cm, B(+S)
5) Fiber reinforced shotcrete and bolting, 5-9cm, Sfr+B
6) Fiber reinforced shotcrete and bolting, 9 - 12cm, Sfr+B
7) Fiber reinforced shotcrete and bolting, 12 - 15cm, Sfr+B
8) Fiber reinforced shotcrete > 15cm, reinforced ribs of shotcrete and bolting, Sfr, RRS+B
9) Cast concrete lining,CCA

KEY ATTRIBUTES	
SH / SV	SH (Adits)
Span (m)	1.5
Height (m)	(1.5)
Rock Mass Class	CR2
Q typical	37.5
Support Category	1

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	-
Bolt length (m)	-
Mesh	
Shotcrete	-
Area (m^2)	-
Number of bolts	-

PILLAR RECONSTRUCTION	
Height (m)	-
Width (m)	-
Length (m)	-
No. of Pillars	-
Volume (m^3)	-

BULKHEAD + GROUTING ADJACENT LOOSE BACKFILL	6 X 2m 48m^3

VOLUME OF TEMPORARY BACKFILL	-

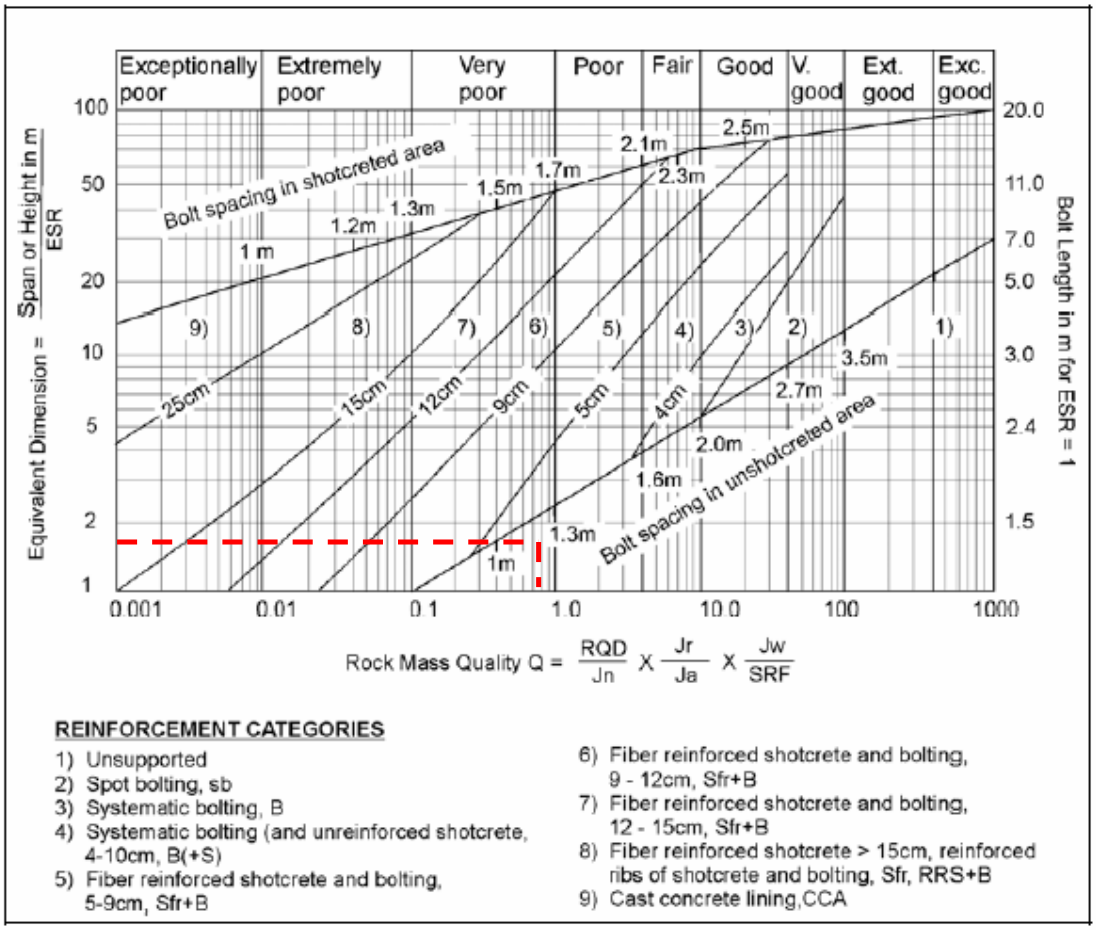
VOLUME OF MATERIAL TO BE EXCAVATED	-

DEWATERING REQUIRED	Yes

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – CARNIC 3 LOWER



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting (and unreinforced shotcrete, 4-10cm, B(+S)
5) Fiber reinforced shotcrete and bolting, 5-9cm, Sfr+B
6) Fiber reinforced shotcrete and bolting, 9 - 12cm, Sfr+B
7) Fiber reinforced shotcrete and bolting, 12 - 15cm, Sfr+B
8) Fiber reinforced shotcrete > 15cm, reinforced ribs of shotcrete and bolting, Sfr, RRS+B
9) Cast concrete lining,CCA

KEY ATTRIBUTES	
SH / SV	SH (Adits G11,20)
Span (m)	1.5
Height (m)	(1.5) locally 3
Rock Mass Class	CR2-Typical CR4-G11
Q typical	0.8
Support Category	4

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	1.6
Bolt length (m)	2.5
Mesh	Double Twist Maccaferri mesh (1000%)
Shotcrete	-
Area (m^2)	24
Number of bolts	12

PILLAR RECONSTRUCTION	
Height (m)	-
Width (m)	-
Length (m)	-
No. of Pillars	-
Volume (m^3)	-

GROUTING ADJACENT LOOSE BACKFILL	-

VOLUME OF TEMPORARY BACKFILL	-

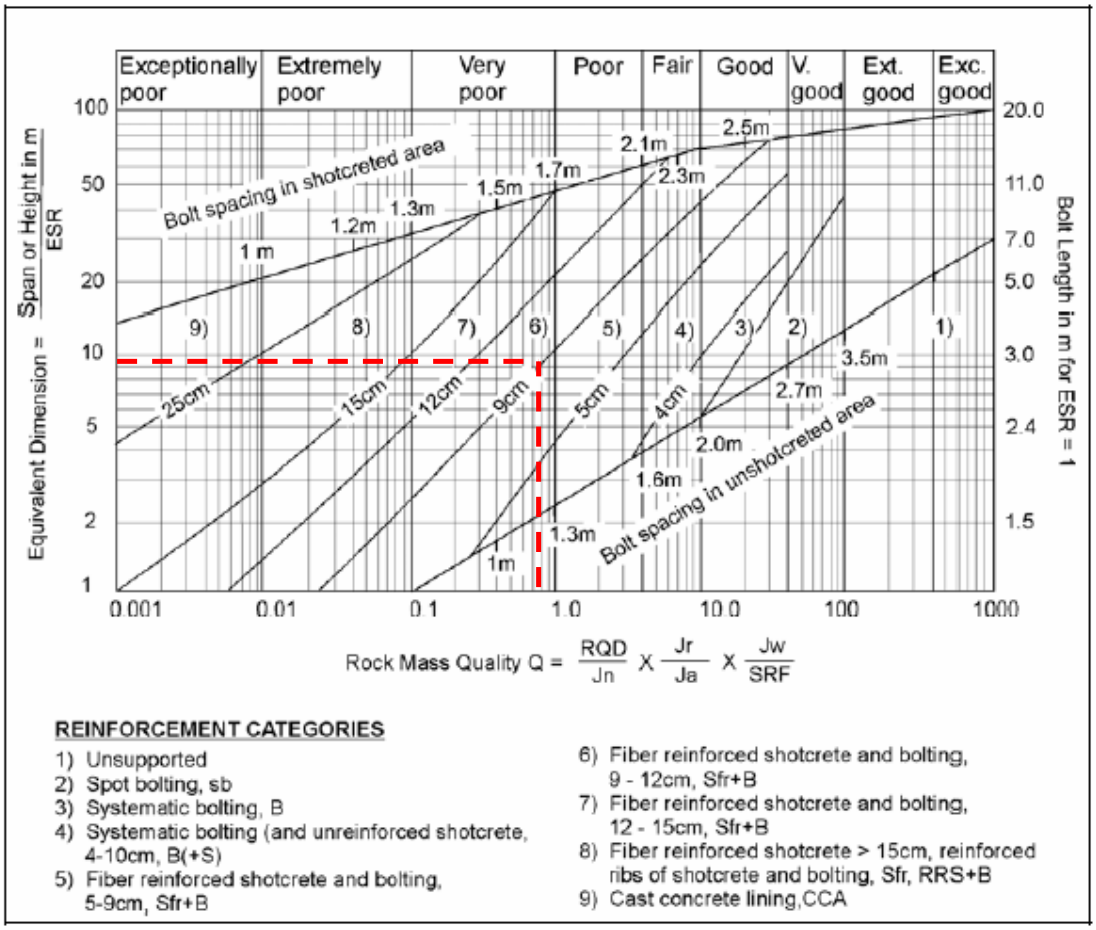
VOLUME OF MATERIAL TO BE EXCAVATED	-

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – CARNIC 3 MIDDLE – ADITS



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting (and unreinforced shotcrete, 4-10cm, B(+S)
5) Fiber reinforced shotcrete and bolting, 5-9cm, Sfr+B
6) Fiber reinforced shotcrete and bolting, 9 - 12cm, Sfr+B
7) Fiber reinforced shotcrete and bolting, 12 - 15cm, Sfr+B
8) Fiber reinforced shotcrete > 15cm, reinforced ribs of shotcrete and bolting, Sfr, RRS+B
9) Cast concrete lining,CCA

KEY ATTRIBUTES	
SH / SV	SH
Span (m)	8-15 (<5)[3]
Height (m)	2.5
Rock Mass Class	CR4
Q typical	0.8
Support Category	5 (& 6)

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	1.6
Bolt length (m)	2.5
Mesh	Heavy Duty mesh 65%
Shotcrete	35% 90mm
Area (m^2)	120
Number of bolts	38

PILLAR RECONSTRUCTION	
Height (m)	2.5
Width (m)	2
Length (m)	2
No. of Pillars	3
Volume (m^3)	30

GROUTING ADJACENT LOOSE BACKFILL	2437.5m^3

VOLUME OF TEMPORARY BACKFILL	-

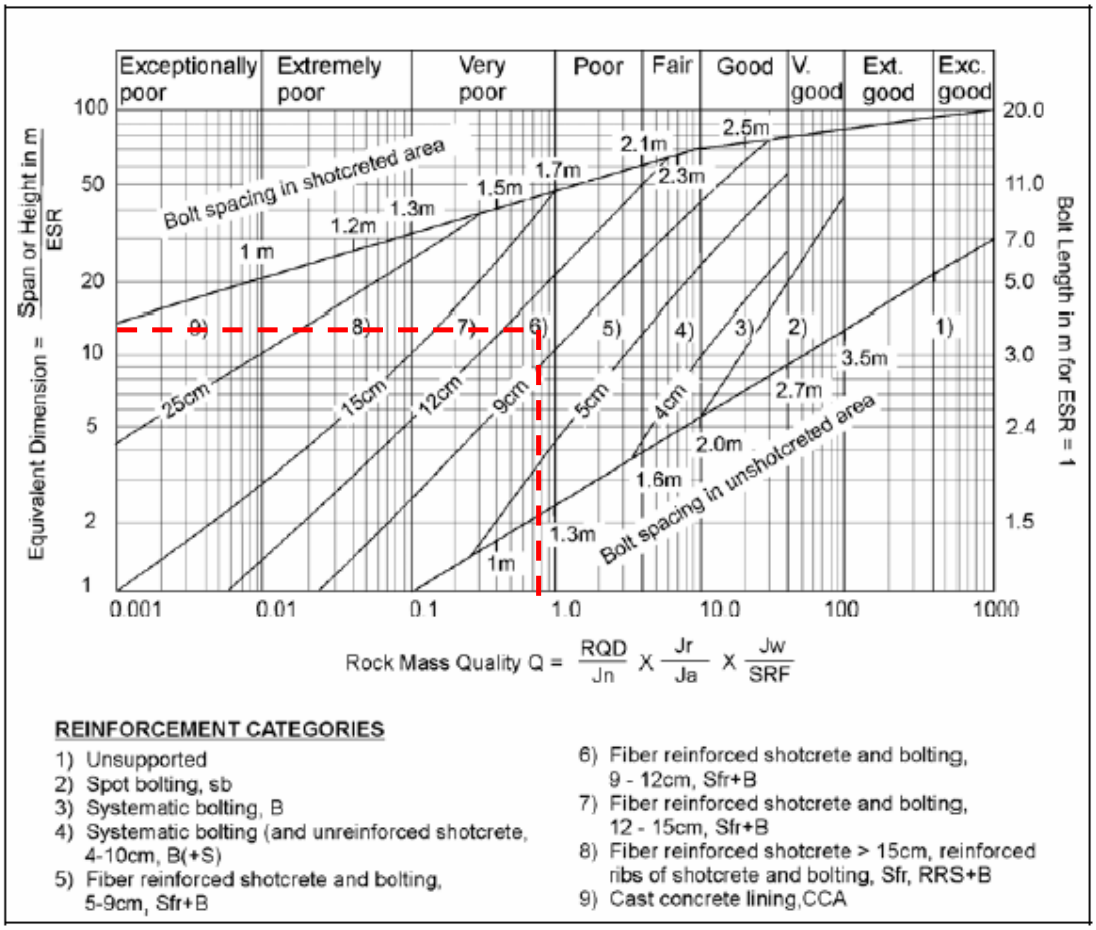
VOLUME OF MATERIAL TO BE EXCAVATED	-

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.
3. Effective span after reconstruction of pillars

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – CARNIC 3 MIDDLE



KEY ATTRIBUTES	
SH / SV	SH (+G2)
Span (m)	10
Height (m)	(4)
Rock Mass Class	CR4
Q typical	0.8
Support Category	6 (& 7)

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	1.6
Bolt length (m)	4.0
Mesh	Double Twist Maccaferri mesh 60%
Shotcrete	40% 90mm
Area (m^2)	116
Number of bolts	36

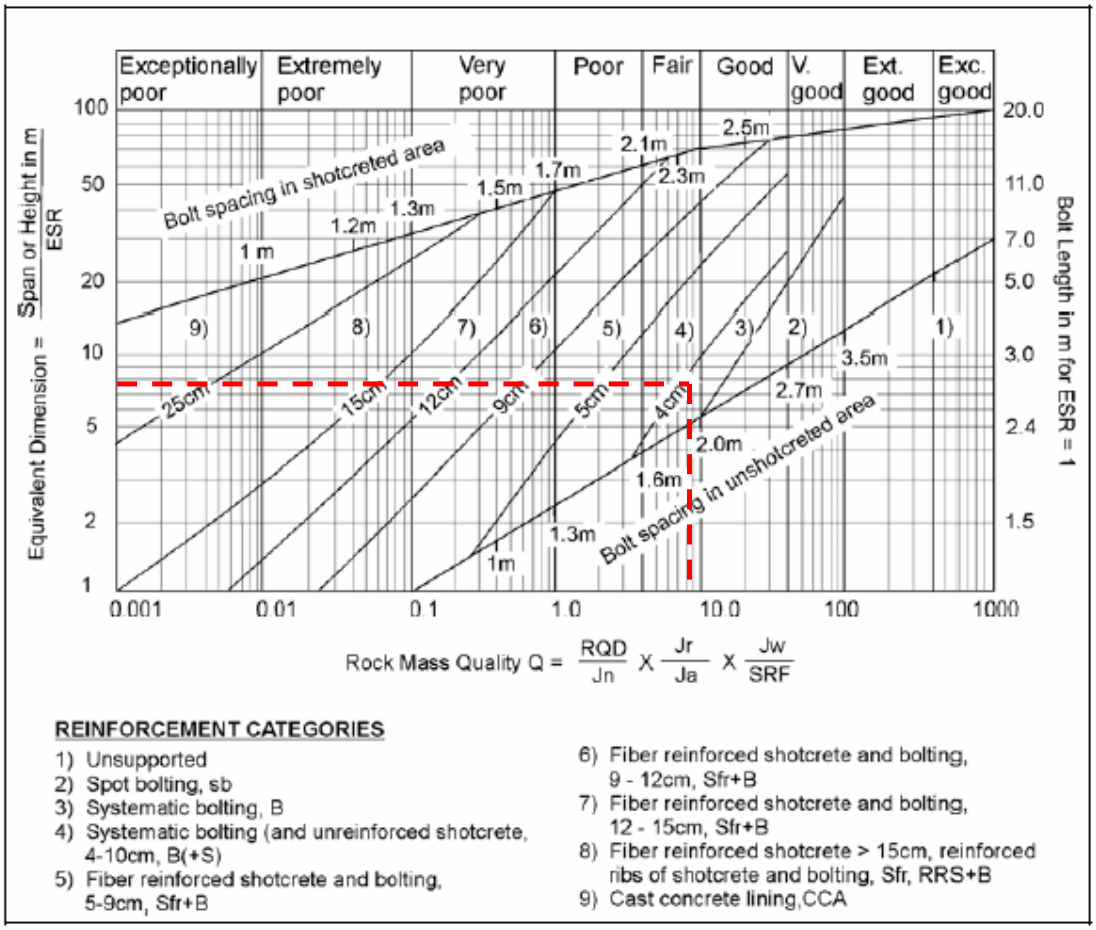
PILLAR RECONSTRUCTION	
Height (m)	4
Width (m)	2
Length (m)	2
No. of Pillars	2
Volume (m^3)	32

GROUTING ADJACENT LOOSE BACKFILL	-
VOLUME OF TEMPORARY BACKFILL	-
VOLUME OF MATERIAL TO BE EXCAVATED	-
DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – CARNIC 3 UPPER



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting (and unreinforced shotcrete, 4-10cm, B(+S)
5) Fiber reinforced shotcrete and bolting, 5-9cm, Sfr+B
6) Fiber reinforced shotcrete and bolting, 9 - 12cm, Sfr+B
7) Fiber reinforced shotcrete and bolting, 12 - 15cm, Sfr+B
8) Fiber reinforced shotcrete > 15cm, reinforced ribs of shotcrete and bolting, Sfr, RRS+B
9) Cast concrete lining,CCA

KEY ATTRIBUTES	
SH / SV	SV (Cor.)
Span (m)	(2)
Height (m)	5-7
Rock Mass Class	SW2
Q typical	8.3
Support Category	4

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	2.5
Bolt length (m)	3.5
Mesh	Heavy Duty Mesh (30%)
Shotcrete	
Area (m^2)	300
Number of bolts	65

PILLAR RECONSTRUCTION	
Height (m)	4
Width (m)	2
Length (m)	2
No. of Pillars	2
Volume (m^3)	32

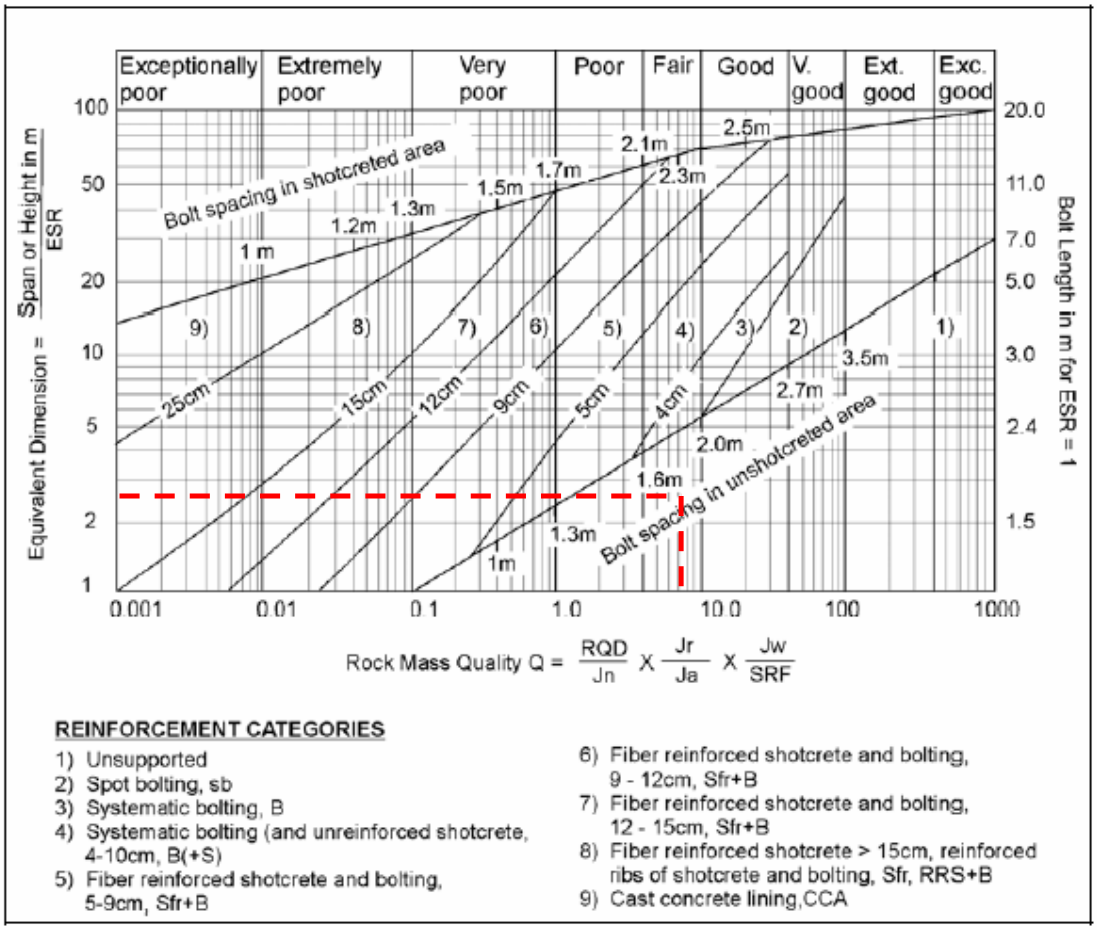
BULKHEAD GROUTING ADJACENT LOOSE BACKFILL	12 X 2m 120m^3
VOLUME OF MATERIAL TO BE EXCAVATED	-

VOLUME OF TEMPORARY BACKFILL	210m^3
DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – CARNIC 5



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting (and unreinforced shotcrete, 4-10cm, B(+S)
5) Fiber reinforced shotcrete and bolting, 5-9cm, Sfr+B
6) Fiber reinforced shotcrete and bolting, 9 - 12cm, Sfr+B
7) Fiber reinforced shotcrete and bolting, 12 - 15cm, Sfr+B
8) Fiber reinforced shotcrete > 15cm, reinforced ribs of shotcrete and bolting, Sfr, RRS+B
9) Cast concrete lining,CCA

KEY ATTRIBUTES	
SH / SV	SV
Span (m)	25
Height (m)	(2)
Rock Mass Class	SW2
Q typical	8.3
Support Category	5

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	2.3
Bolt length (m)	2.5
Mesh	Heavy Duty Mesh (30%)
Shotcrete	-
Area (m^2)	1600
Number of bolts	348

PILLAR RECONSTRUCTION	
Height (m)	-
Width (m)	-
Length (m)	-
No. of Pillars	-
Volume (m^3)	-

GROUTING ADJACENT LOOSE BACKFILL	-

VOLUME OF TEMPORARY BACKFILL	2040m^3

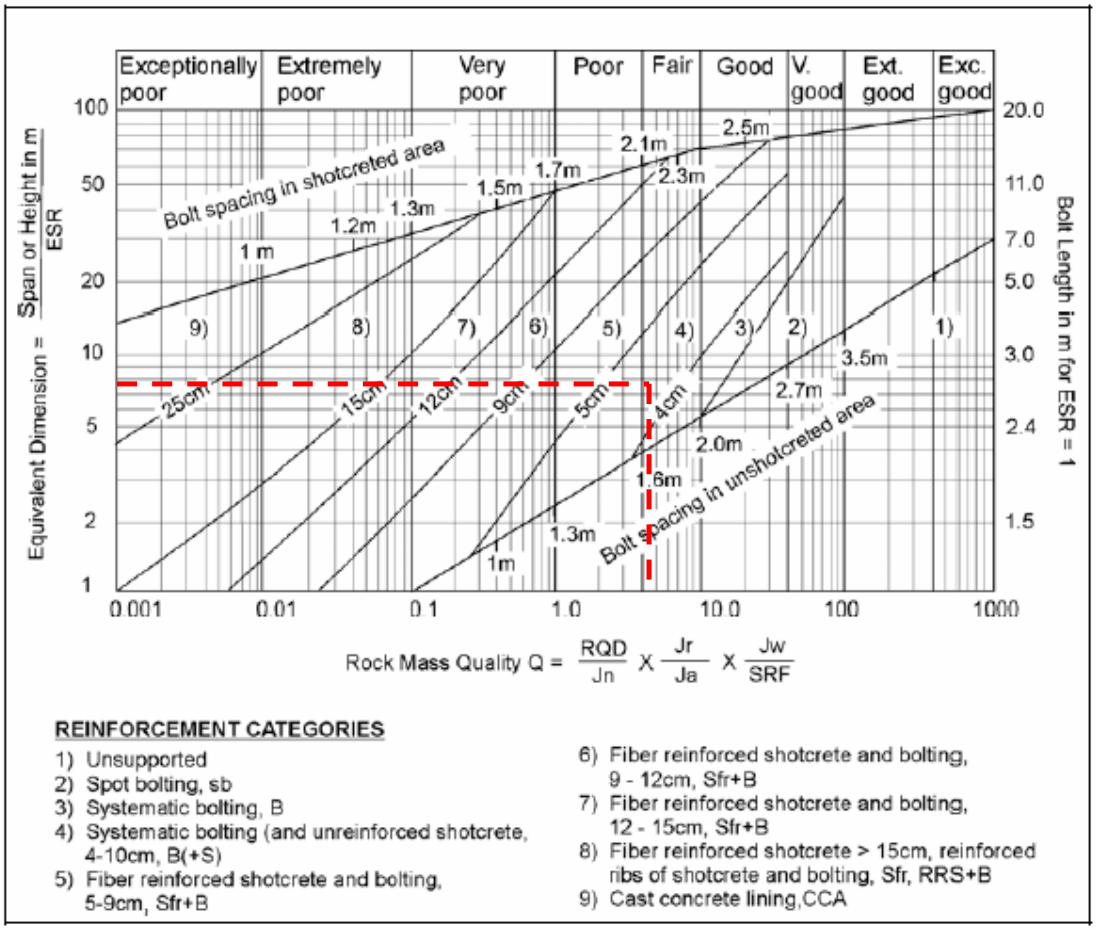
VOLUME OF MATERIAL TO BE EXCAVATED	-

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – CARNIC 6



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting (and unreinforced shotcrete, 4-10cm, B(+S)
5) Fiber reinforced shotcrete and bolting, 5-9cm, Sfr+B
6) Fiber reinforced shotcrete and bolting, 9 - 12cm, Sfr+B
7) Fiber reinforced shotcrete and bolting, 12 - 15cm, Sfr+B
8) Fiber reinforced shotcrete > 15cm, reinforced ribs of shotcrete and bolting, Sfr, RRS+B
9) Cast concrete lining,CCA

KEY ATTRIBUTES	
SH / SV	SH
Span (m)	6
Height (m)	(2)
Rock Mass Class	CR4
Q typical	5.3
Support Category	4

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	2.1
Bolt length (m)	3.5
Mesh	Double Twist Maccaferri mesh (30%)
Shotcrete	-
Area (m^2)	52
Number of bolts	12

PILLAR RECONSTRUCTION	
Height (m)	-
Width (m)	-
Length (m)	-
No. of Pillars	-
Volume (m^3)	-

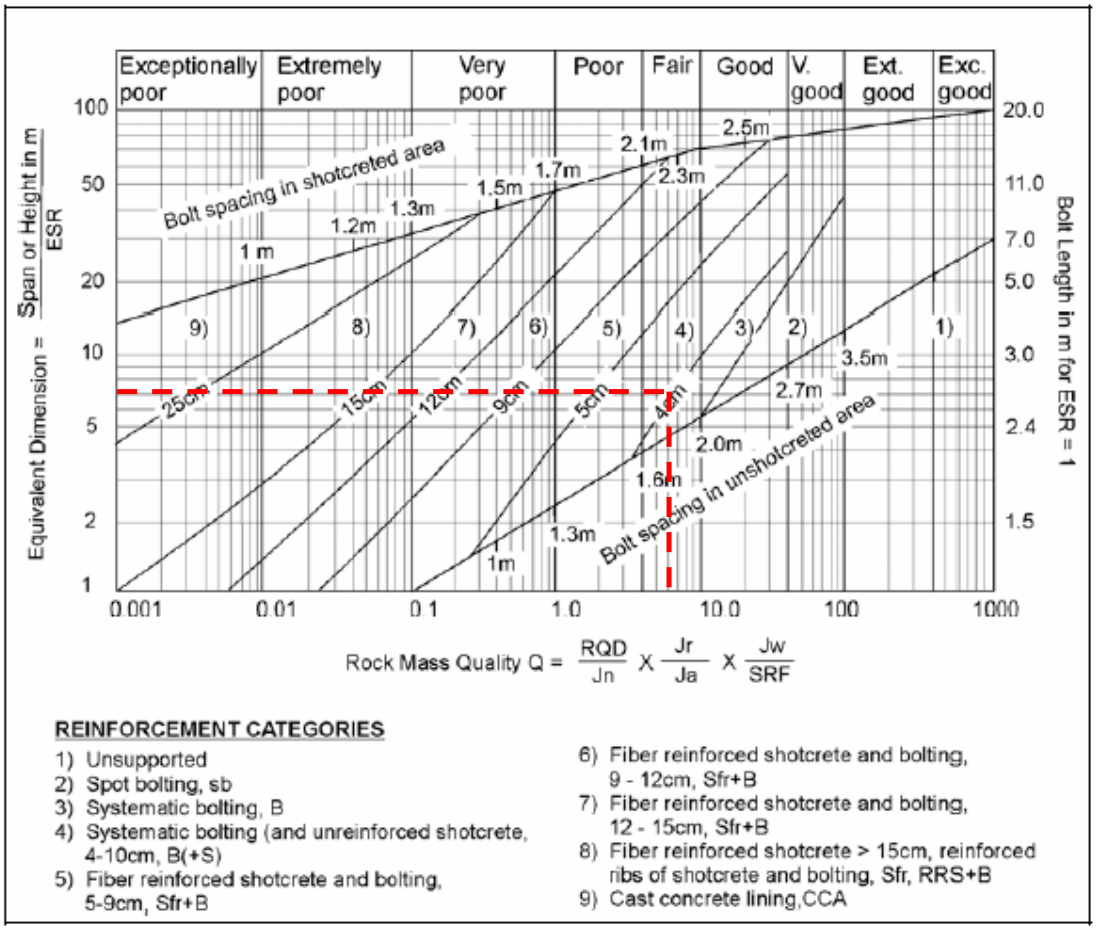
BULKHEAD GROUTING ADJACENT LOOSE BACKFILL	15 X 2m 117m^3
VOLUME OF MATERIAL TO BE EXCAVATED	-

VOLUME OF TEMPORARY BACKFILL	-
DEWATERING REQUIRED	Yes

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – CARNIC 9 LOWER



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting (and unreinforced shotcrete, 4-10cm, B(+S)
5) Fiber reinforced shotcrete and bolting, 5-9cm, Sfr+B
6) Fiber reinforced shotcrete and bolting, 9 - 12cm, Sfr+B
7) Fiber reinforced shotcrete and bolting, 12 - 15cm, Sfr+B
8) Fiber reinforced shotcrete > 15cm, reinforced ribs of shotcrete and bolting, Sfr, RRS+B
9) Cast concrete lining,CCA

KEY ATTRIBUTES	
SH / SV	SV
Span (m)	(2)
Height (m)	6
Rock Mass Class	SW2
Q typical	8.3
Support Category	4

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	2.3
Bolt length (m)	3.5
Mesh	Double Twist Maccaferri mesh (30%)
Shotcrete	-
Area (m^2)	50
Number of bolts	11

PILLAR RECONSTRUCTION	
Height (m)	-
Width (m)	-
Length (m)	-
No. of Pillars	-
Volume (m^3)	-

GROUTING ADJACENT LOOSE BACKFILL	-

VOLUME OF TEMPORARY BACKFILL	-

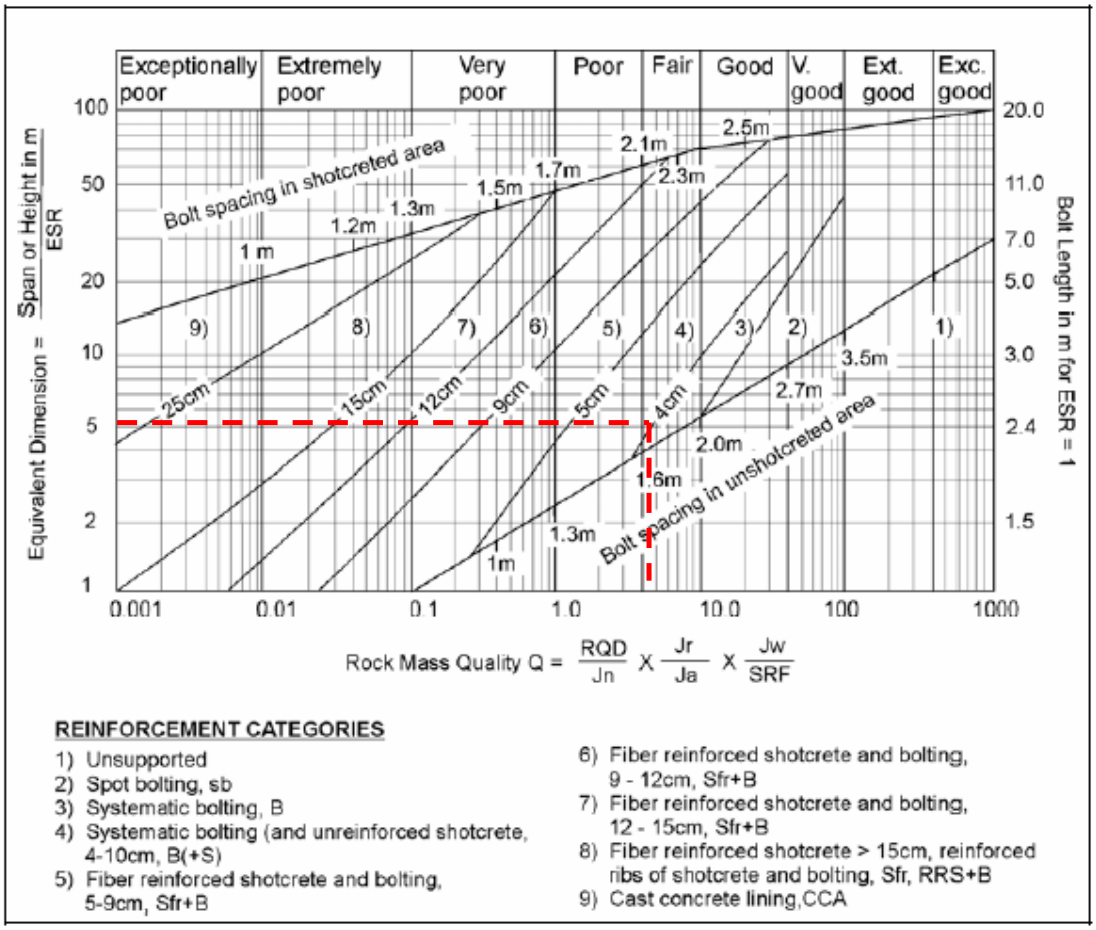
VOLUME OF MATERIAL TO BE EXCAVATED	-

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – CARNIC 9 MIDDLE



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting (and unreinforced shotcrete, 4-10cm, B(+S)
5) Fiber reinforced shotcrete and bolting, 5-9cm, Sfr+B
6) Fiber reinforced shotcrete and bolting, 9 - 12cm, Sfr+B
7) Fiber reinforced shotcrete and bolting, 12 - 15cm, Sfr+B
8) Fiber reinforced shotcrete > 15cm, reinforced ribs of shotcrete and bolting, Sfr, RRS+B
9) Cast concrete lining,CCA

KEY ATTRIBUTES	
SH / SV	SH
Span (m)	4
Height (m)	(2)
Rock Mass Class	CR2
Q typical	5.3
Support Category	4

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	2.1
Bolt length (m)	3.0
Mesh	Double Twist Maccaferri mesh (30%)
Shotcrete	-
Area (m^2)	16
Number of bolts	4

PILLAR RECONSTRUCTION	
Height (m)	-
Width (m)	-
Length (m)	-
No. of Pillars	-
Volume (m^3)	-

GROUTING ADJACENT LOOSE BACKFILL	-

VOLUME OF TEMPORARY BACKFILL	-

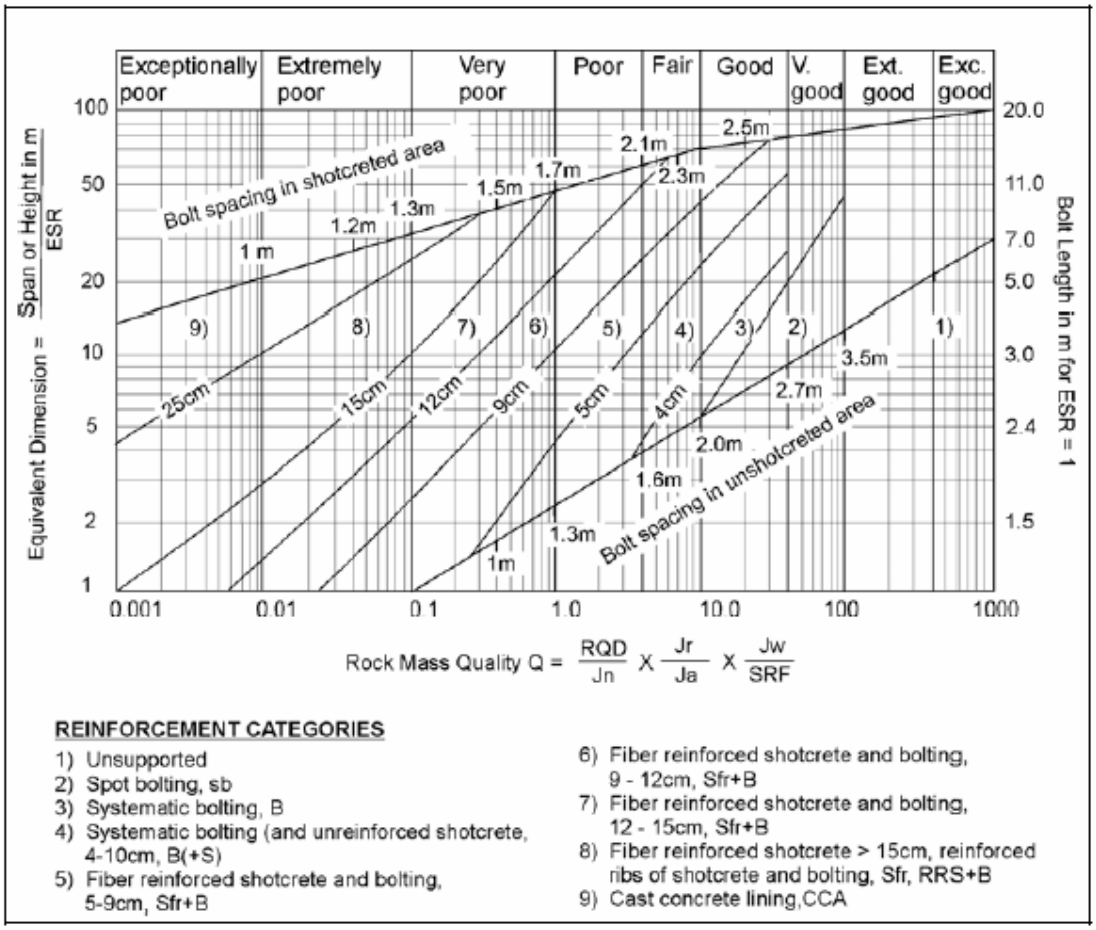
VOLUME OF MATERIAL TO BE EXCAVATED	-

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – CARNIC 9 UPPER



KEY ATTRIBUTES	
SH / SV	-
Span (m)	-
Height (m)	-
Rock Mass Class	-
Q typical	-
Support Category	-

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	-
Bolt length (m)	-
Mesh	-
Shotcrete	-
Area (m^2)	New 45m Tunnel
Number of bolts	-

PILLAR RECONSTRUCTION	
Height (m)	-
Width (m)	-
Length (m)	-
No. of Pillars	-
Volume (m^3)	-

GROUTING ADJACENT LOOSE BACKFILL	-

VOLUME OF TEMPORARY BACKFILL	-

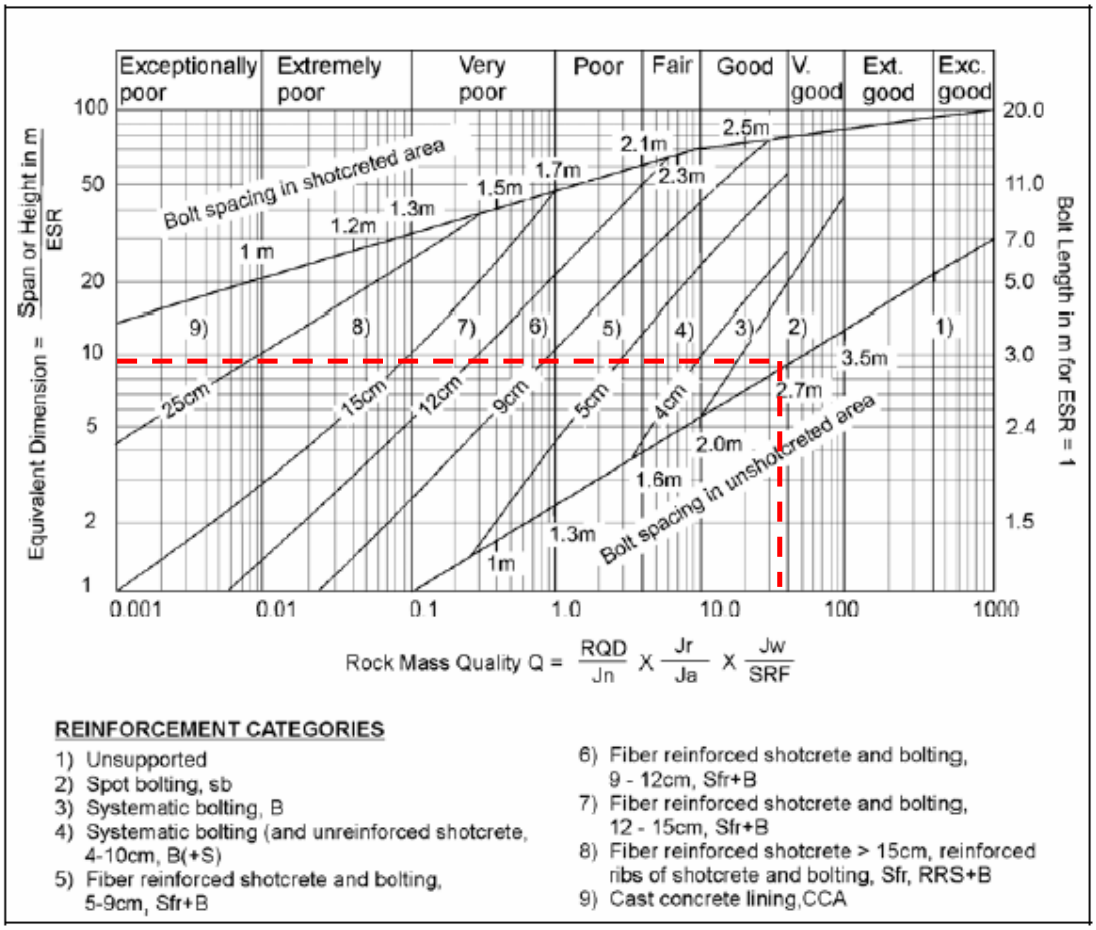
VOLUME OF MATERIAL TO BE EXCAVATED	-

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – CARNIC 9 C



KEY ATTRIBUTES	
SH / SV	SH
Span (m)	8
Height (m)	(2)
Rock Mass Class	CR2
Q typical	37.5
Support Category	3

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	2.8
Bolt length (m)	4.0
Mesh	Double Twist Maccaferri mesh (30%)
Shotcrete	-
Area (m^2)	81
Number of bolts	14

PILLAR RECONSTRUCTION	
Height (m)	2
Width (m)	1.5
Length (m)	1
No. of Pillars	10
Volume (m^3)	30

BULKHEAD + GROUTING ADJACENT LOOSE BACKFILL	30 X 4m 200m^3

VOLUME OF TEMPORARY BACKFILL	-

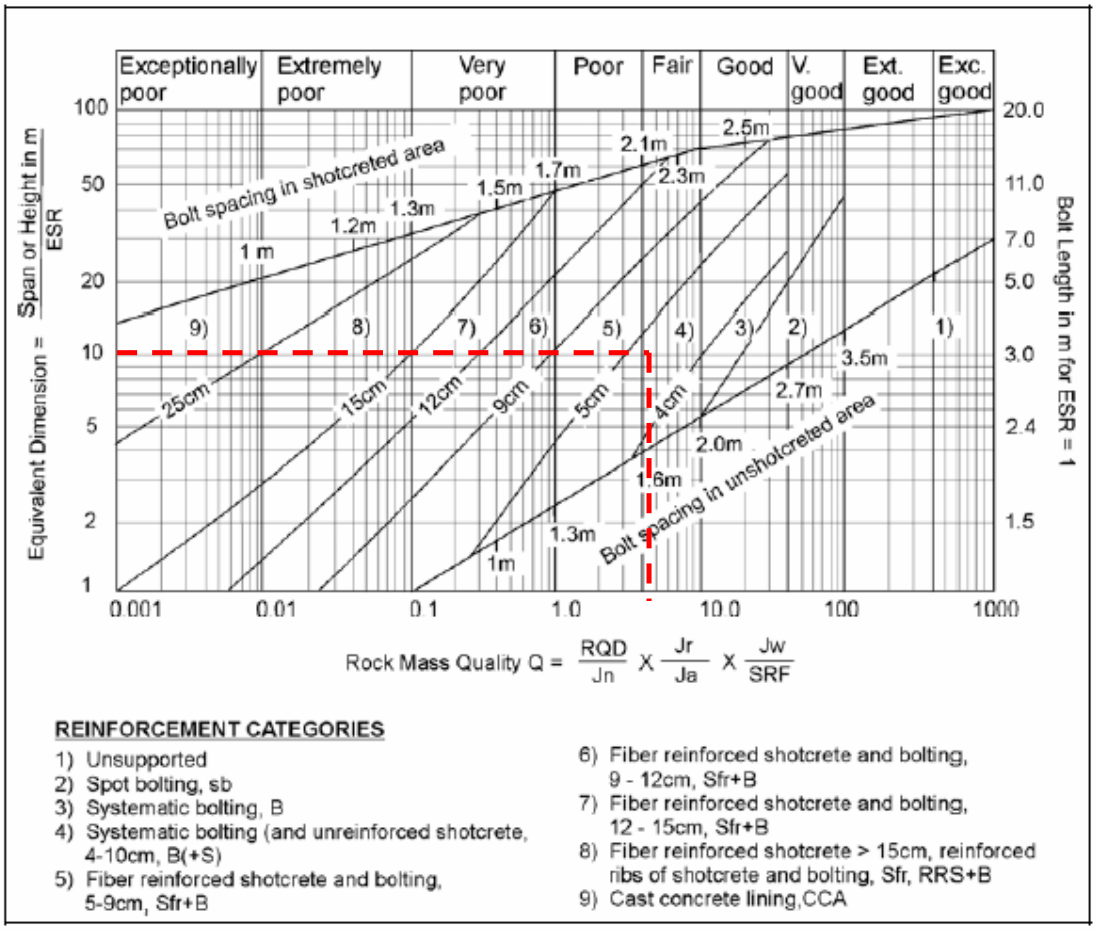
VOLUME OF MATERIAL TO BE EXCAVATED	125m^3

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – CARNIC 10 LOWER



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting (and unreinforced shotcrete, 4-10cm, B(+S)
5) Fiber reinforced shotcrete and bolting, 5-9cm, Sfr+B
6) Fiber reinforced shotcrete and bolting, 9 - 12cm, Sfr+B
7) Fiber reinforced shotcrete and bolting, 12 - 15cm, Sfr+B
8) Fiber reinforced shotcrete > 15cm, reinforced ribs of shotcrete and bolting, Sfr, RRS+B
9) Cast concrete lining,CCA

KEY ATTRIBUTES	
SH / SV	SH
Span (m)	8
Height (m)	(2)
Rock Mass Class	CR4
Q typical	5.3
Support Category	6

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	2.1
Bolt length (m)	4.0
Mesh	Heavy Duty Mesh 65%
Shotcrete	90mm 35%
Area (m^2)	70
Number of bolts	17

PILLAR RECONSTRUCTION	
Height (m)	2
Width (m)	8
Length (m)	15
No. of Pillars	2
Volume (m^3)	480

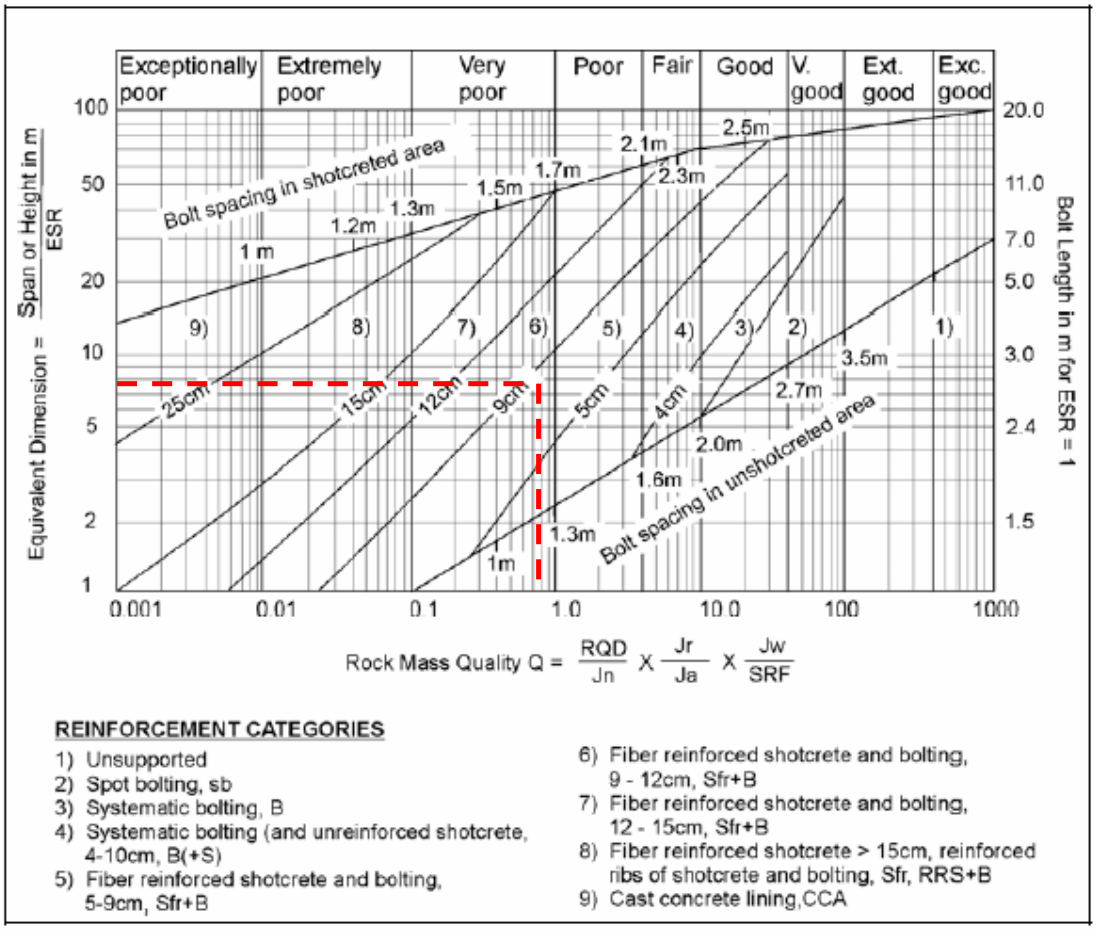
BULKHEAD + GROUTING ADJACENT LOOSE BACKFILL	6x1.5 45m^3
VOLUME OF MATERIAL TO BE EXCAVATED	360m^3

VOLUME OF TEMPORARY BACKFILL	-
DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – CARNIC 10 MIDDLE



KEY ATTRIBUTES	
SH / SV	SH
Span (m)	(12-16) D2 = 6
Height (m)	(2)
Rock Mass Class	CR4
Q typical	0.8
Support Category	(3-4) D2 = 6

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	D2 = 2.2
Bolt length (m)	D2 = 3.5
Mesh	Heavy Duty mesh
Shotcrete	-
Area (m^2)	D2 = 72
Number of bolts	16

PILLAR RECONSTRUCTION	
Height (m)	6
Width (m)	2
Length (m)	45
No. of Pillars	1
Volume (m^3)	540

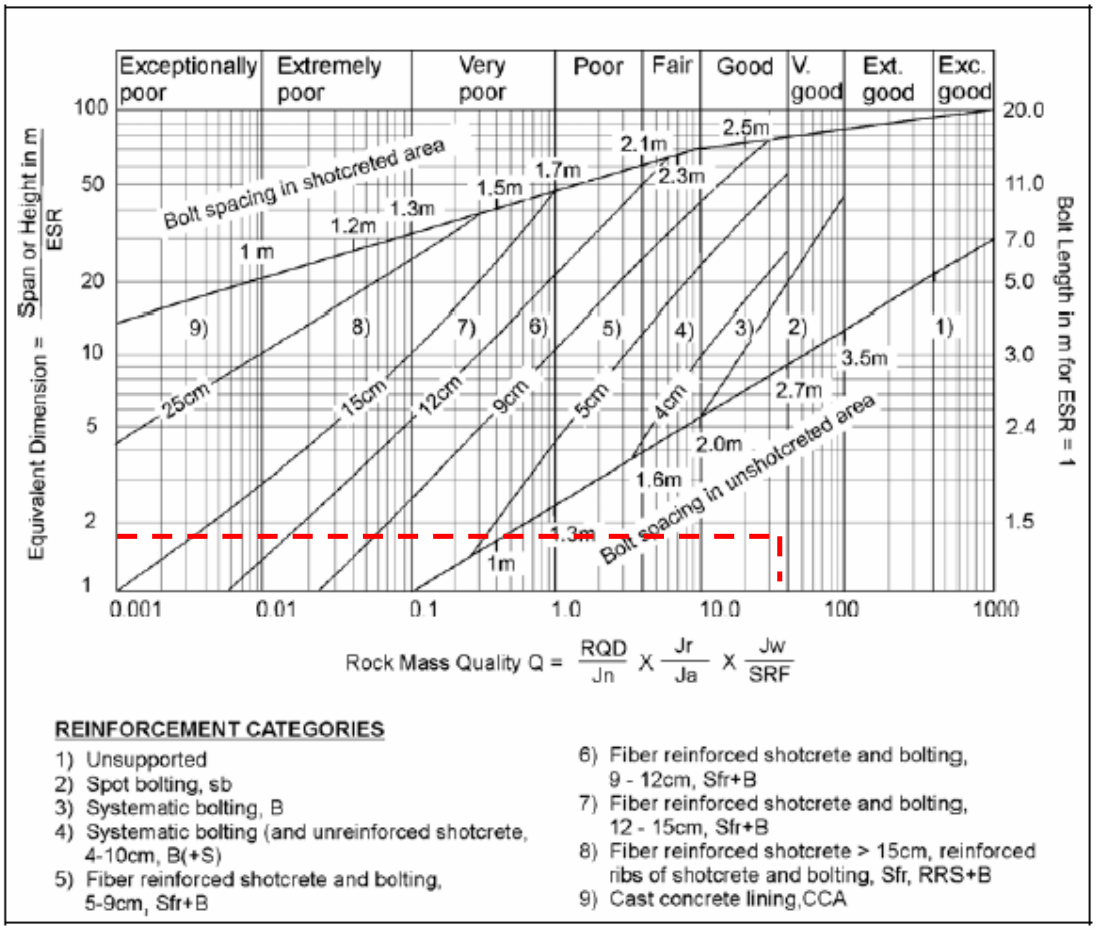
BULKHEAD + GROUTING ADJACENT LOOSE BACKFILL	10 X 1.5 $75m^3$
VOLUME OF MATERIAL TO BE EXCAVATED	$21m^3$

VOLUME OF TEMPORARY BACKFILL	-
DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – CARNIC 10 UPPER/INTERMEDIATE



KEY ATTRIBUTES	
SH / SV	SH (Adit)
Span (m)	1.5
Height (m)	(1.5)
Rock Mass Class	CR2 (CR4)
Q typical	37.5 (0.8)
Support Category	1 (4)

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	1.6
Bolt length (m)	2.5
Mesh	Double Twist Maccaferri mesh
Shotcrete	-
Area (m^2)	22.5
Number of bolts	7

PILLAR RECONSTRUCTION	
Height (m)	-
Width (m)	-
Length (m)	-
No. of Pillars	-
Volume (m^3)	-

BULKHEAD + GROUTING ADJACENT LOOSE BACKFILL	10 x 2m 80m^3

VOLUME OF TEMPORARY BACKFILL	-

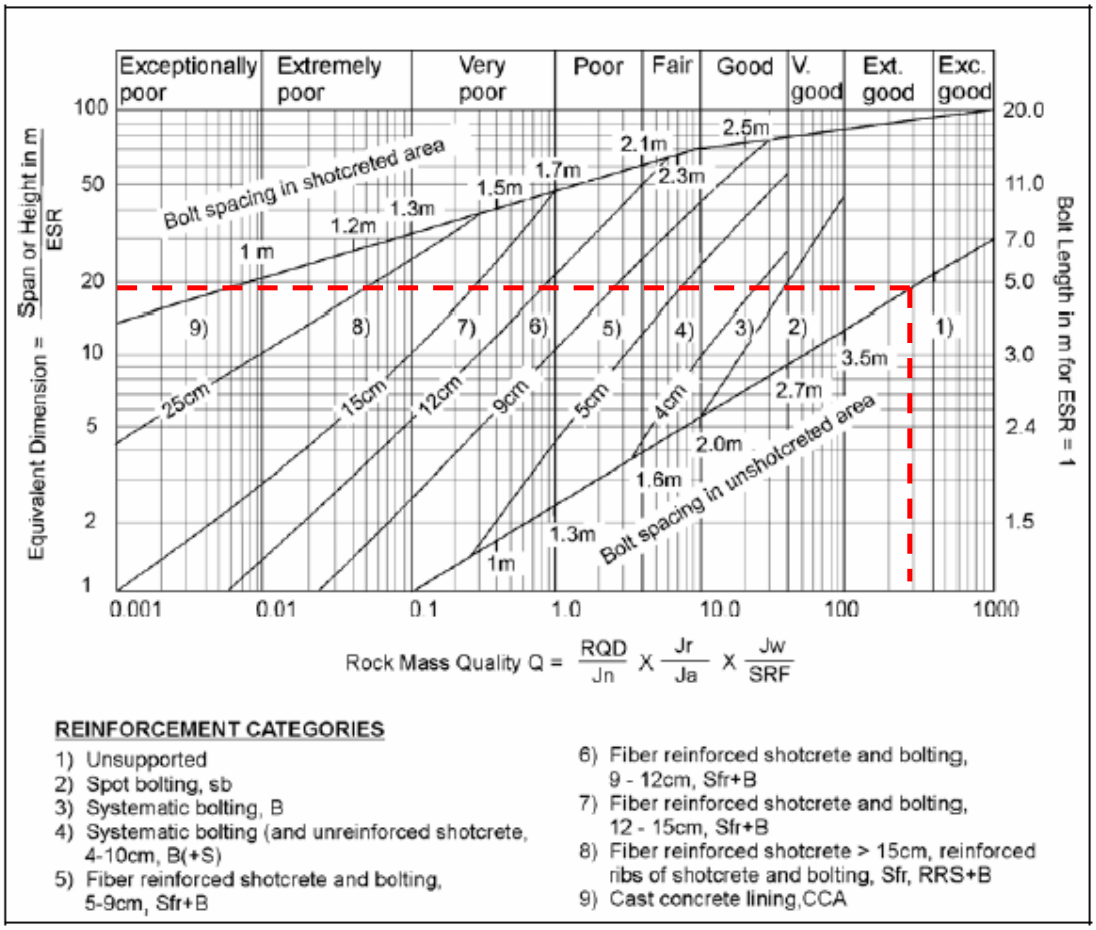
VOLUME OF MATERIAL TO BE EXCAVATED	-

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – CARNIC 13



KEY ATTRIBUTES	
SH / SV	SV
Span (m)	(4)
Height (m)	15
Rock Mass Class	CR1
Q typical	120
Support Category	2

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	3.5
Bolt length (m)	4.5
Mesh	
Shotcrete	-
Area (m^2)	1600
Number of bolts	229

PILLAR RECONSTRUCTION	
Height (m)	4
Width (m)	2
Length (m)	2
No. of Pillars	4
Volume (m^3)	64

GROUTING ADJACENT LOOSE BACKFILL	-

VOLUME OF TEMPORARY BACKFILL	Rope access and wooden platform only

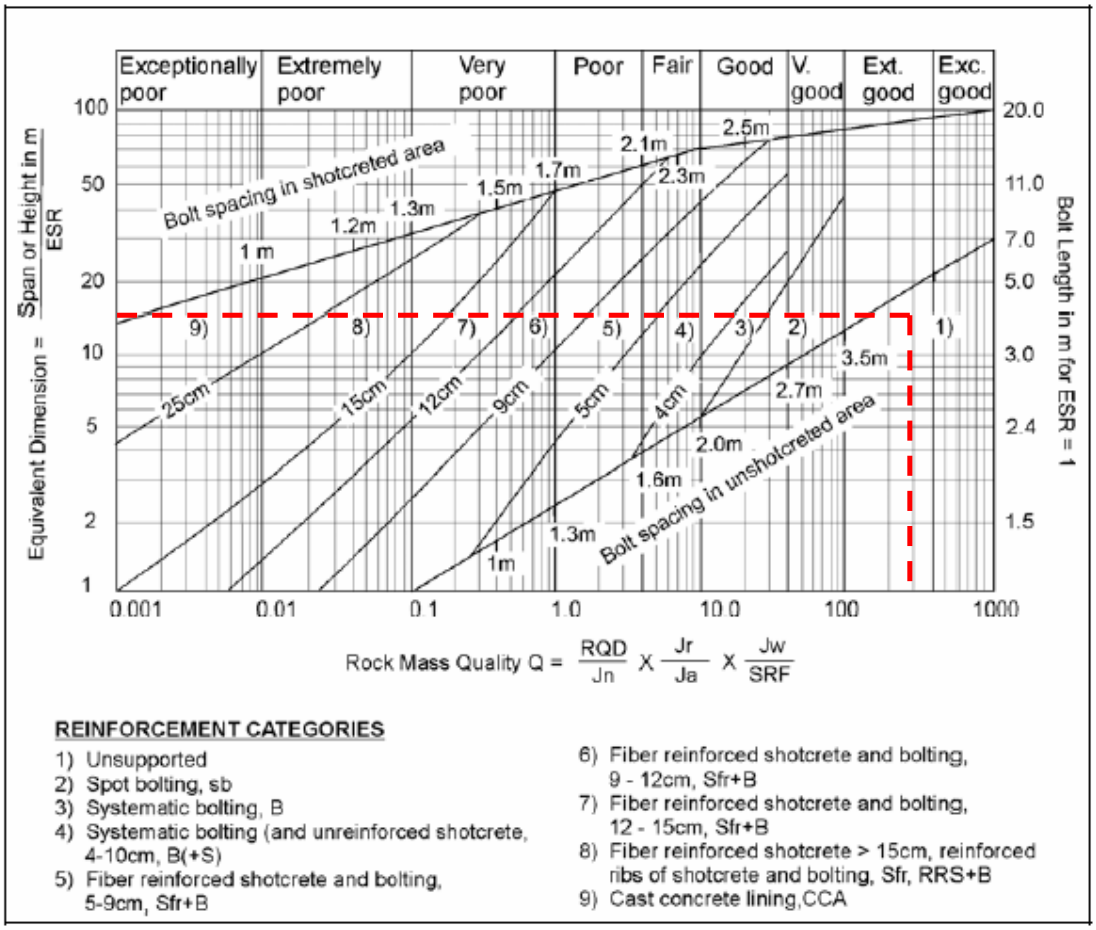
VOLUME OF MATERIAL TO BE EXCAVATED	-

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – CARNIC 21



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, sb
3) Systematic bolting, B
4) Systematic bolting (and unreinforced shotcrete, 4-10cm, B(+S)
5) Fiber reinforced shotcrete and bolting, 5-9cm, Sfr+B
6) Fiber reinforced shotcrete and bolting, 9 - 12cm, Sfr+B
7) Fiber reinforced shotcrete and bolting, 12 - 15cm, Sfr+B
8) Fiber reinforced shotcrete > 15cm, reinforced ribs of shotcrete and bolting, Sfr, RRS+B
9) Cast concrete lining,CCA

KEY ATTRIBUTES	
SH / SV	SV
Span (m)	(4)
Height (m)	12
Rock Mass Class	CR1
Q typical	120
Support Category	2

SUPPORT REQUIREMENTS	
Bolt Spacing (m)	3.5
Bolt length (m)	4.5
Mesh	-
Shotcrete	-
Area (m^2)	960
Number of bolts	137

PILLAR RECONSTRUCTION	
Height (m)	4
Width (m)	2
Length (m)	2
No. of Pillars	4
Volume (m^3)	64

GROUTING ADJACENT LOOSE BACKFILL	$80m^3$

VOLUME OF TEMPORARY BACKFILL	Rope access and wooden platform only

VOLUME OF MATERIAL TO BE EXCAVATED	-

DEWATERING REQUIRED	No

NOTES :

1. ESR of 0.8 applied consistent with public access.
2. Reduction of Q x 0.5 adopted to take into account 3D loading effects and geological / geometrical uncertainty.

ROSIA MONTANA - MINE MUSEUM STUDY
MINE STABILISATION REQUIREMENTS - ANCIENT WORKINGS
Q ASSESSMENT AND DESIGN CHART – CARNIC 22

APPENDIX C

MAJOR QUANTITIES

ROSIA MONTANA GOLD MINE – MAJOR QUANTITIES

Shafts

Precast concrete bolted segmental - underpinned

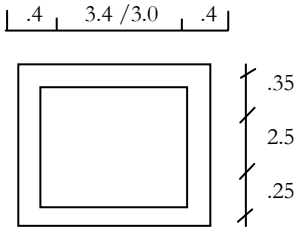
Ref	Dia	Area	Depth	Exc	Rings	Extra Work
1	4.57	23	28	644	46	Sink shaft inside massif
2	4.57	23	40	920	66	
3	4.57	23	105	1608	172	Enlarge existing
4	4.57	23	21	483	34	
Coranda	4.57	23	40	240	66	Enlarge existing
			234	3895	384	

Lifts

No design – use Alimac type lifts
4 Nr lengths 28 + 40 + 105 + 21

Adits

Enlarge existing Concrete Lined



Size 3.4 x 2.5 Area = 13m²
3.0 x 2.5 Area = 12m²

Ref	Size	Area	Length	Exc	Conc	Mesh	Extra Work
1	8.5	9.0	400	3600	1800	5600	Train widen at platform
2	8.5	6.5	45	293	203	630	
3	7.3	5.5	175	962	735	2450	
4	7.3	5.5	420	2310	1764	5880	
5	7.3	8.0	200	1600	840	2800	
6	7.3	5.8	50	290	210	700	widen at platform
7	8.5	6.8	190	1292	855	2660	" " "
8	7.3	6.0	100	600	420	1400	
9	8.5	6.8	320	2176	1440	4480	Train widen at platform
10	7.3	5.8	160	928	672	2240	
11	8.5	7.0	195	1365	878	2730	
12	8.5	13.0	50	650	225	700	unstable ground
13	8.5	13.0	50	650	225	700	unstable ground
14	8.5	7.0	95	665	428	1330	
15	8.5	7.2	70	504	315	980	
16	8.5	6.8	80	544	360	1120	
17	8.5	6.7	50	335	225	700	
			2,650	18,764	11,594	37,100	

ROSIA MONTANA GOLD MINE – MAJOR QUANTITIES

Backfill Existing Roadways

Fill Roadways (3.0 x 2.4 approx) with Sand/Cement grout

Level	Length	Volume	Cement	Sand
958	1210m	8834	-	-
932	530m	3869	-	-
960	693m	5180	-	-
978	100m	730	-	-
	2533m	18,613	2,700	2,7000

Temporary Roadways

Access required to stabilise Coranda Corhuri
Roadway size (2.4 x 2.5)

Level	Size	Area	Length	Exc	Conc
998	6	5	310	1550	1240
984	6	5	280	1400	1120
958	6	5	340	1700	1360
932	6	5	350	1725	1400
			1280	6375	5120

Support 60m of room + pillar
" 100m " " "

Backfill Room & Pillar Workings

Level	Volume	Total Length	Cement	Sand	Bulkhead
1-9	54183	643	-	-	665
10	11797	140	-	-	140
11-23	91510	1086	-	-	1100
1-10	42974	510	-	-	530
	20,0464	2379	29,000	29,2000	2435

Access to Room & Pillar Workings

Adit Level	Length	Shafts Level	Depth	Workings Level	Length
1	50	1-9	91	1-23	3100
3	80	10	24		
10	480	11-23	141		
14	575		256		
17	210				
20	260				
	1655				

ROSIA MONTANA GOLD MINE – MAJOR QUANTITIES

Coranda Corhuri

Existing height is 180m of which 70% is filled with discard and collapsed material

Grout existing fill to 958 level

Volume = 73010m^3 Cement = 10,600t
Sand = 106,00t

Temp fill to stabilize upper levels

Volume = 78225m^3

Stabilise Upper Coranda

Exc temp fill	78225m^3
Rock bolts 10m long	1540Nr
Mesh	9625m^2

ROSIA MONTANA GOLD MINE – MAJOR QUANTITIES

Ventilation

	Volume of Tour Areas	Vol
Shafts	4.57 dia x 234m	3860
Adits	13132 + 8066 + 7680	28878
Rm& Pillar		11797
Access		9930
Coranda		78225
Roman	Approx	50000
		182,690

Lighting & Services

		Length
Shafts		234
Adits	2650 + 1280 + 1655	5585
Coranda		400
Roman		1000
		7219

Roman Workings

			WORKINGS			ROCK BOLTS			PILLAR RECONSTRUCTION	GROUT FILL	TEMP FILL	EXC FILL
			Span	Ht	Area	Space	Length	Nr	Nr x W x L x Ht = M³	M³	M³	M³
Carnic	1	Lower	7	1.5	156	2.3	3.5	34	-	-	-	-
	1	Middle	12	3	152	2.8	4.5	27	3 x 2 x 2 x 3 = 36	-	560	776
	1	Upper	10	3-6	274	2.8	4.5	49	3 x 2 x 2 x 6 = 72	-	450	530
G101 &	D17		2	6	165	2.3	3.5	36	1 x 1 x 1 x 5 = 5	-	500	500
Carnic	2	Lower	2	2	-	-	-	-	-	-	-	-
	2	Middle	10	2-3	125	2.8	4.0	22	-	-	-	35
	2	Upper	10	2-3	-	-	-	-	-	-	-	-
	2	S/Wall	2.5	9	126	2.4	4.0	26	-	-	52	332
	2	Crown	5	2.25	70	2.8	3.5	13	-	-	52	87
Carnic	3	Lower	1.5	1.5	-	-	-	-	-	48	-	-
	3	Adits	1.5	1.5	24	1.5	2.5	12	-	-	-	-
	3	Middle	8-15	2.5	120	1.6	2.5	38	3 x 2 x 2 x 2.5 = 30	2438	-	-
	3	Upper	10	4	116	1.6	4.0	36	2 x 2 x 2 x 4 = 32	-	-	-
Carnic	5		2	5-7	300	2.5	3.5	65	2 x 2 x 2 x 4 = 32	120	210	210
Carnic	6		25	2	1600	2.3	2.5	348	-	-	2040	2040
Carnic	9	Lower	6	2	52	2.1	3.5	12	-	117	-	-
	9	Middle	2	6	50	2.3	3.5	11	-	-	-	-
	9	Upper	4	2	16	2.1	3.0	4	-	-	-	-
Carnic	10	Lower	8	2	81	2.8	4.0	14	10 x 1 x 1.5 x 2 = 30	200	-	125
	10	Middle	8	2	70	2.1	4.0	17	2 x 8 x 15 x 2 = 480	45	-	360
	10	Upper	6	2	72	2.2	3.5	16	1 x 45 x 2 x 6 = 540	75	-	21
Carnic	13		1.5	1.5	23	1.6	2.5	7	-	80	-	-
Carnic	21		4	15	1600	3.5	4.5	229	4 x 2 x 2 x 4 = 64	-	-	-
Carnic	22		4	12	960	3.5	4.5	137	4 x 2 x 2 x 4 = 64	80	-	-
Total Quantities					6152			1153	=1385	3203	3864	5016

Amount of work per Rock Bolt

Each rock bolt Av 3.6m long at 2.3 centres
Fix 5m2 of mesh
Temp support 5m of roof with 3.3m3 temp fill + 4.3 exc of fills.
60% of rock bolting is in Carnic 6, 21 + 22

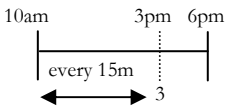
APPENDIX D

MUSEUM BUILDINGS

ROSIA MONTANA MINE - MUSEUM BUILDINGS

Maximum Visitor Numbers

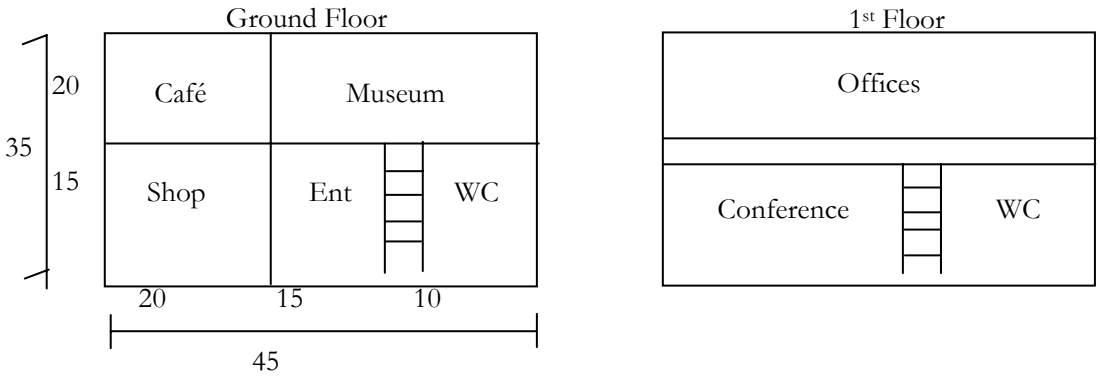
3hr visit



Total Nr/day = 6 x 4hr x 15Nr = 360day
Total Nr/yr = 360 x 7 x 50 x 75% = 94500 per year

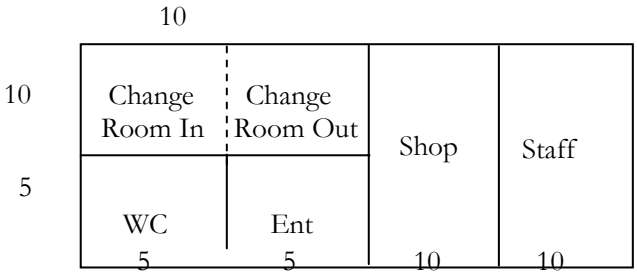
Visitors at centre/day = 360 + 50% = 540day per day
length of visit = ½day each party 270 at any time
say parking for 100 – 150 car spaces

Visitor Centre



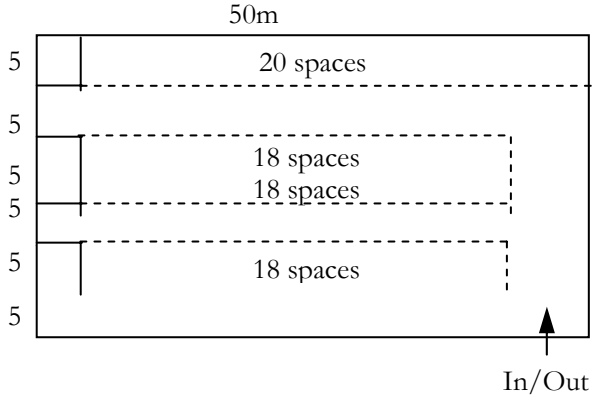
Floor Area = 2/35 x 45 = 3150m²

Mine Building



= Floor Area = 450m²

Car Parking



Area = 1500m²
Spaces = 74Nr
kerbs = 160m
drains = 150m

APPENDIX E

PROGRAMME - CRITICAL PATH ACTIVITIES OUTPUTS

Mine Construction

Shafts

Ref	Depth	Output	Setup	Wks
S1	28	3	3+2	14
S2	40	3	2+1	16
S3	105	3	3+2	40
S4	21	3	2+1	12
Coranda	40	3	1	14

Adits

Level	Ref	M	Wks	
958	1.2.3.6	670	76	9m/wk +1wk floors
958/960/978	7.8.13-17	635	71	" " "
932	9-12	725	82	" " "
850/958	4.5	620	70	" " "

Fill Existing Roadways

Level	Length	Fill	Wks	Bulkheads
958	1210	8834	4	17
932	530	3869	1½	7
960	693	5180	2	10
978	100	730	½	2

Access to Room & Pillar

Adits (Propped)	Length	Wks	Work
Access	1655	83	Reprop Adit
Workings	3100	172	Form safe access
Shafts	256	19	37 shafts 4.6m high

Fill Room Pillar

Level	Fill	Wks
1-10	65980	13
S/W	42974	9
11-23	91510	19

Note:

Alternatively surface drill to lower levels without the need to construct bulkheads as detailed. It will still be necessary to access levels 1 – 10 to form bulkheads unless done from Coranda Corhuri.

Roman Workings

Carnic	Area	Bolts	Conc	Gt	Fill	Exc	Wks
1-3	1328	293	175	2486	1614	2260	54
5-6	1900	413	32	120	2250	2250	48
13-21/22	2583	373	128	160	-	-	16
9-10	341	74	1320	320	-	1826	32

Possibly require surface drilling for grouting and placing of fill

Tunnel	Length	Wks
Carnic 9	45	6

Coranda Corhuri

Grout Fill

40% void	Fill	Wks
All	73010	16

Possibly require drilling from 958 level

Access for Stabilisation

Level	Length	Wks
932	350	40
958	340	38
984	280	32
998	310	34

Rockfill Coranda

Level	Fill	Wks	
1-10	78225	16	Add for setup & moving

Require surface drilling at 10m and spin stone in at top ie. 16 holes x 40m deep.

Excavate & Rock Bolt

Level	Exc	Wks	
1-3	12725	10	90% taken out shaft
3-10	65550	34	Add for setup & moving