"Parameters of the Norwegian Q-system and geological conditions correlated with grout take in the JA1 Skaugum Railroad Tunnel"

Cand. Scient. Thesis in Engineering and Structural Geology

by

Elin K. Morgan

Department of Geosciences

University of Oslo

April 2004

Acknowledgements

This thesis has come about by the cooperation between The Norwegian Geotechnical Institute (NGI), the Norwegian Railroad Development Department (Jernbaneverket Utbygging) and the Department of Geosciences at the University of Oslo.

I would like to take the opportunity to thank the following contributors to making this thesis possible.
First of all I want to thank my professors Kaare Høeg and Fredrik Løset who gave me the opportunity to write this thesis, and who have been truly inspirational, helpful and patient as I have worked my way through the chapters presented.

Furthermore I would like to thank the crew at JBV JA1 building offices at Bikkjedammen for their helpfulness every week I went to collect data, and for the great time I had working with the project the summer of 2003. Special thanks to Johan Mykland, the only true geologist among the project engineers, Per Arne Moen for Autocad compilations and Arnstein Aarset for answering my many questions on engineering subjects.
I would also like to thank Mattias Hagestuen of the contractor MIKA's office for his patience and cooperation during the weeks I worked alone, and for easing the job I had as a Control engineer during the summer of 2003.

A thank is definitely in place for Jan K Holme of NGI for helping me with the mysteries of Microsoft Excel, and to Professor Arild Andresen for help on understanding the structural geology of the Oslo Region. Thanks to Professor Odd Nilsen for explaining the complexities of the Oslo Rift and for being such a nice guy to talk to.

My fellow students are thanked for contributing to a great time at the Institute of Geosciences and for always making me feel a part of something fruitful.
Thanks to Post Doc.s Reidar Müller and Henrik Svensen for many laughs and dinner breaks, and to Marie Østensen,Victoria Adestål, Andreia Marques, Tor E. Aas and Raymond Bekkeheien for good times during long study hours.

Special thanks go to Camilla Fjeldheim who has been an incredible friend to have, and has helped me beyond expectation with reproducing the geologic profile in Adobe Illustrator.

An enormous thank you must go to my friends Linda, Karen and Jannecke who have stood by my side for the total 6 years it has taken me to obtain my degree. How ever did you stand it?

Last but not least I want to thank my family represented by my mom, dad and my step mom, my brother and my son for unconditional love, support and understanding.
My son Jørgen has been a true source of inspiration, and my brother has been of great help every time my computer broke down or I needed a baby sitter.
To my boyfriend Paal: I love you. Thank you for enduring the periods of stress and frustration.

Finally I want to thank my aunty Hil. I would never have become a geologist if it hadn't been for her.

Abstract

"Parameters of the Norwegian Q-system and geological conditions correlated with grout take in the JA1 Skaugum Railroad Tunnel"

Elin K. Morgan

Department of Geosciences, University of Oslo, P.O Box 1047 Blindern, N-0316 Oslo, Norway.

Since its development in 1974 the Q-system for classifying rock masses has readily been used for dimensioning support measures in underground excavations in Norway and internationally. The Q-system, as it was originally developed, is based on 6 parameters where two and two make up ratios describing degree of fracturing, frictional conditions along joints and stress conditions in the rock mass.

During the past decade there has been an increasing interest in investigating any other fields of application for this classification system, for instance to predict leakage into tunnels and potential grout take.

In this thesis, it is of main interest to see whether or not the Q-value or the system parameter values determined along the trace of the JA1 Skaugum Railroad Tunnel exhibit any correlation to the amount of grout injected into the rock mass to control leakage. Unfortunately, the results of the re-working of data in this thesis cannot support a correlation between the Q-value or its parameters and the grout take. Secondly, it has been of interest to establish any relationship between the amount of injected grout and the geology within this specific section of the Oslo Region. This has given more promising results, as there seems to be a correlation between lithology and grout take, structural geologic variations and grout take, and orientation of the joint sets of the section and grout take. Additionally, there seems to be an indication that competent rocks, such as sand- and limestones have higher grout takes than clay- and nodular limestone shales. There also seems to be an indication that rock masses intercepted by dikes and folded strata have higher grout takes than faulted rock masses and adjacent rock. In addition, joint sets oriented perpendicular to the direction of the minor principal stress, exhibits increased grout take.

The conclusions from this thesis are that lithology, structural geologic features and joint orientations are reflected in the grout take to the tunnel and should be taken into account when a grouting scheme or prognosis is made for new projects. A routine application of Q-parameter values without the correlation with these features is too limited and does not seem fruitful.

Table of Contents

Chapter 1

Introduction

1.1 Introduction to the thesis

Several previously built tunnels in Norway have had severe water leakage problems during and after their construction causing serious delays and complications. Leakages into tunnels drain the ground water reserve and may lower the water table. In the event of a lowered ground water table, overlying loose sediments may experience subsidence due to changes in effective stresses. The cost of the tunnels in question increased by a vast amount in addition to the fact that the time it took to meet safety and leakage requirements was unsatisfactory. This gave rise to an increasing interest and demand for a faster, safer and cost reducing strategy on how to avoid major leakage problems and lowering of the ground water table during and after tunnel construction.

There have been several case studies performed during the past twenty years in Norway to determine major potential water inflow- and weakness zones in the rock mass, relating them to the parameters of the Q-system. In addition to several previous reports, the Norwegian Geotechnical Institute (NGI) has a series of reports written under the project "Miljø og samfunnstjenelige tunneler". These reports cover a broad spectrum of problem settings, but they all have in common the fact that they illuminate the problems encountered during construction and analyze the solutions applied to solve them. Several individual reports focus on the parameters of the Q-system and how these relate to leakage rates and grout take. These reports have been reviewed during the preparation of this thesis.

The results and the discussion in this thesis are based on the data collected and analyzed from the Norwegian Railroad Development project:
Skøyen – Asker: The New Double Track; the JA1 Skaugum Tunnel.
As the excavation of the tunnel is not completed within the time frame of this thesis, the data used only represent those of the already excavated tunnel.

1.2 Scope

The objective of my work is to seek an explanation to the varying quantities of grout needed to meet leakage and stability requirements in the Skøyen-Asker Railroad Tunnels, and relate them to the geological conditions, with emphasis on the parameters of the Norwegian Q-system.

This thesis will consider the connections between geological conditions and the Q-system and its parameters versus the amount of grout needed to bring the respective tunnels to standard along the trace of the JA1 Skaugum Tunnel.

Rock type and the structures within the rock mass, including igneous intrusions, affect tunnel leakage and stability. Most importantly it is of interest to find which parameters of the Q-system and which geological features are most related to the grout take, as this may be of help in making future grouting prognosis.
The conclusions of this thesis may contribute to further understanding of the factors influencing the grout take during tunnel construction, and hopefully illuminate the actions needed to make the strategy of grouting more cost effective.

1.3 Thesis schedule

The thesis work was started in September 2002. The collecting of data from the JA1-tunnel commenced at the same time and terminated in October 2003. From that point on the data have been systemized, reworked, interpreted and discussed.

1.3.1 Collecting data

Weekly trips to the JBV JA1 tunnel office were made from September 2002 until October 2003 to collect available data and to enter the tunnel to do my own investigations. Geological and engineering geological mapping of the tunnel was done continuously as the construction of it proceeded.
The data collected were grout take print-outs for each grout curtain, the tunnel mapping forms used by the control engineers and several Autocad compilations of the geology and internal support measures along the tunnel trace. The consultants maps USA72-6-T-V02002 and USA75-6-T-JA1 have also been used actively.

June to August 2003 was spent working as a control engineer at the same office. This presented a unique opportunity to follow the daily construction work and to use the Q-system actively as well as to be able to be on site as construction proceeded and problems were encountered and solved.

1.3.2 Problems along the way

There have been few problems of a severe character during the preparation of this thesis, but two need to be mentioned.

- The updated Autocad files used to re-construct the geologic profile along the trace of the tunnel have only been accessible at rare intervals, often with a delay of several weeks and months.
- Due to the fact that shotcrete is one of the immediate measures used for securing the tunnel for working purposes, cross-checking data with the true conditions in the tunnel has been almost impossible as the rock surface was covered up. Also, by the fact that the data is collected from an engineering and not a geologic point of view, a lot of useful and necessary geologic information has been lost.

In addition to this, there was a remarkable difference in working with the tunnel construction on a daily basis compared to the weekly visits to the site. I gained a much better appreciation of the situation through the daily work.

1.4 The Skøyen-Asker Project

1.4.1 Geographic location

Skøyen is located in the western part of Oslo, the capital of Norway. Oslo is situated in the south-eastern part of the country at the head of the Oslo Fjord. The city has 510 000 inhabitants and is Norway’s largest. Figure 1.1 gives an overview of the geographic locations described in the proceeding text, and the location of the trace of the JA1 and JA2 tunnels.

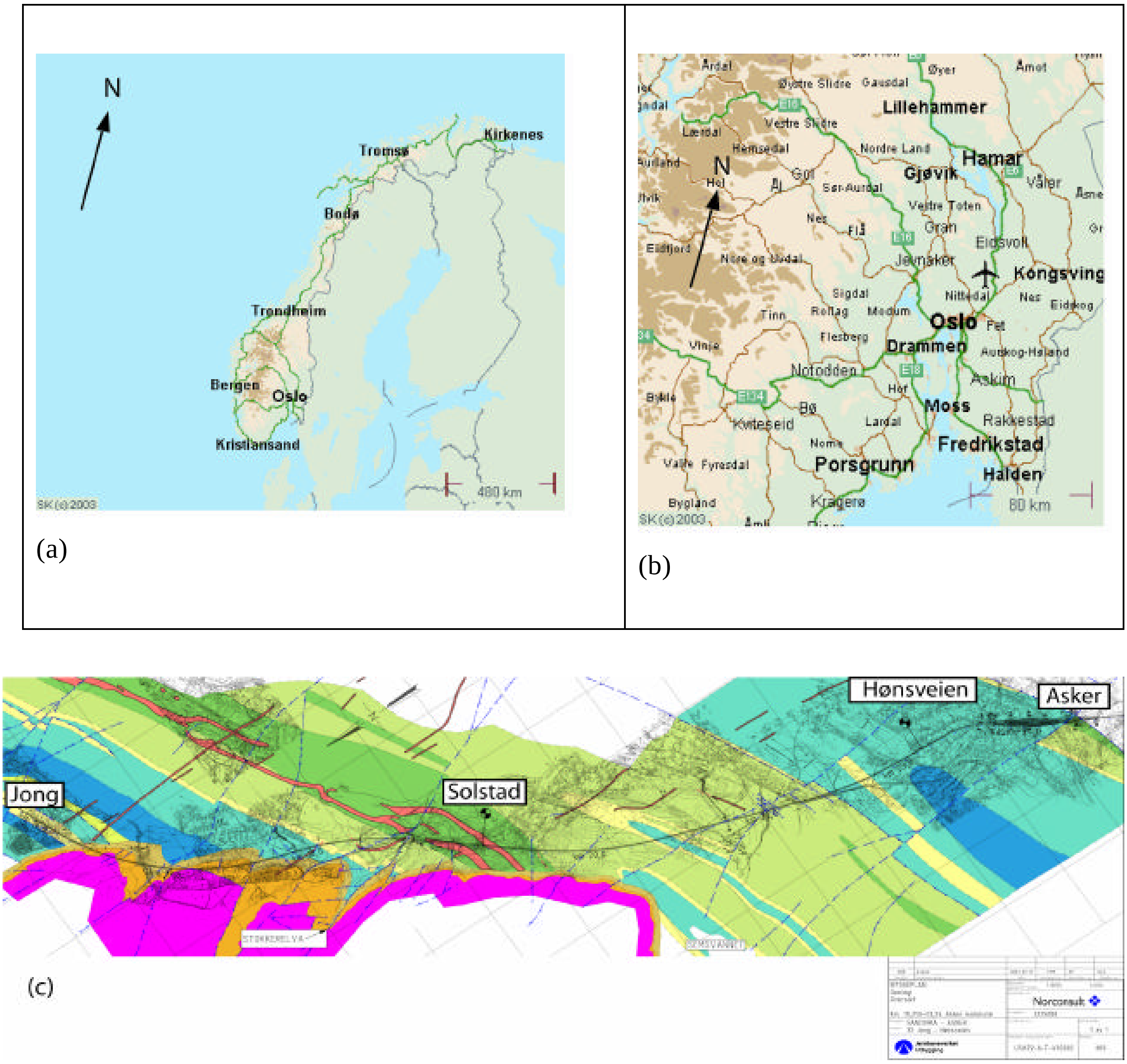


Figure 1.1 Map of Norway (a) and the Oslo area (b). Modified from www.kvasir.no, 2003. (c) The traces of the JA1 and JA2 tunnels. Modified from Norconsult map USA72-6-T-V02002.

In the vicinity of Oslo, in all directions, there are several smaller towns. Many of the inhabitants of these peripheral towns work in the city and are dependant on transport to and from work every day.

Oslo's largest peripheral city 40 km to the south-west is Drammen. Drammen is Norway's largest sea port. Transportation of goods and daily commute between the two cities is large. Asker is situated half way between the two.

1.4.2 Initial railroad standard

Presently, all railroad traffic between Oslo and Asker is conducted along two tracks, one in each direction. This implies that all trains, freight and passenger, travel along these two tracks. Any incident occurring on that track, technical or other, has a major impact on the rest of the traffic along it, and delays and complications are inevitable.
To solve this problem and also the demand for a faster and safer commute, a new section of this heavily trafficated railroad has been planned. Accordingly, the first section is now under construction.

1.4.3 The Jong – Asker tunnels

The project in total includes two new high-speed tracks in hard rock tunnels from Skøyen (Oslo) to Asker (Akershus).
The tunnel system comprises of a total 19,5 km. The final stretch will consist of four tracks as the project comes to a close in 2011.

The section Jong-Asker takes up 6,9 km of the total 19,5 km and is presently under construction. By plan it is expected to be finished in 2005. The building of the section Jong - Skøyen has not yet commenced, but is expected to be finished by 2011.

The Jong-Asker section consists of two tunnels, the J1A Skaugum and the JA2 Tanum tunnels. The JA1 Skaugum tunnel will have a length of 3.6 km, while the JA2 Tanum tunnel will have a length of 2.7 km.

There is a 600m long day-zone between the two tunnels at Åstad and Solstad. The tracks will not run in tunnels at this location due to safety precautions and the presence of an existing train stop.

1.4.4 Tunnel construction

The JA1 and JA2 tunnels are being built by the Norwegian National Railroad Administration (JBV) and their department of development (JBV Utbygging).
The two tunnels have different contractors as there was a general invite of tenders before construction commenced.

The JA1 tunnel is constructed by MIKA A/S, the JA2 tunnel by AF Spesialprosjekt A/S.

Both tunnels are driven through hard rock although some locations have minimal rock cover. Tunnel construction is done by the classical “drill and blast” method and not by the newer method of TBM (Tunnel Boring Machine). This is mostly a result of cost effective strategy. JBV Utbygging and MIKA A/S agreed to construct the JA1 tunnel with three working faces. Two initial working faces were started from the mid-point of the JA1 tunnel and the third from Asker Centre, the end-point. Tunnel construction of the latter commenced May 2003.

Prior to drilling and blasting, a grout curtain is installed around the contour of the tunnel. By this the rock is injected with micro- and industrial cement to ensure better tunnel stability and water tightness before excavation.
Safety measures in the form of bolts, bands and sprayed concrete are executed as the tunnel proceeds. The amount of support measures needed per blast is calculated by assistance of the empirical Q-method.

In the specific locations of small rock cover above the tunnel or in areas where the trace of the tunnel runs through unconsolidated sediments, concrete linings are installed. Concrete lining is also installed in zones of weakness where the rock conditions and tunnel stability are poor.

1.4.5 Groundwater monitoring

In the light of unwanted leakage incidents that have occurred during the construction of previously built tunnels, great attention has been paid to the water tightness and water inflow restrictions of the JA1 and JA2 tunnels during their construction.
To keep track of the variations in the level of the ground water table and ground water pressures before and during construction, several wells with pressure sensors have been installed along the traces of both tunnels. The monitoring program is set up by NGI and the data is available through a specific web-site. Fluctuations that may exceed the normal background variations may therefore be registered and dealt with before any severe damage may occur.

Chapter 2

Geology of the Oslo Region

2.1 Introduction

The geology of the Oslo Region is described to some detail in this chapter in order to give the reader a better understanding of the complexities of the geology in the region and to better explain the results and conclusions from the re-working of data in Chapters 6 and 7. Section 2.6 describes the geology along the JA1 Skaugum tunnel in relation to the geology of the region. The geology along the JA2 Tanum tunnel is not specifically presented as this thesis does not include data from that tunnel.

2.2 The Oslo Rift

The Oslo Region constitutes a geological province where rocks of Pre-Cambrian to Triassic age are preserved in a rift structure formed by extension of the crust during the period of Carboniferous to Early Triassic (Dons & Larsen 1978, Larsen et al. 1995).

The Rift is interpreted to be a passive rift formed as a response to the Hercynic Mountain building further south in Europe and marks the beginning of a period of extension and volcanic activity throughout North Western Europe, culminating in the opening of the Atlantic Ocean.

The Region is orientated NNE-SSW and covers a 35-65 km wide and 220 km long zone from the Mjøsa area in the North to the outer parts of the Oslo Fjord (Langesund) in the south. The rift structure extends yet 200 km into the Skagerak Sea, terminating in the Tornquist-Teiseyre Line. See Figure 2.1 below for details.

The Oslo Graben, i.e. the segment of the Oslo Rift situated between Mjøsa and Langesund, consists of two half-grabens; the Vestfold Graben to the south and the Akershus Graben to the north. These two segments are separated by the Isidalen-Krokkleiva Fault, a NW-SE oblique-slip fault running by the city of Oslo. See Figure 2.2 for details.

The East- and Western perimeters are limited by the previously mentioned half-graben fault zones, orientated N-S and separating the surrounding Pre-Cambrian Basement rocks from the Cambro-Silurian sedimentary and volcanic rocks of the rift (Ramberg et al. 1977).

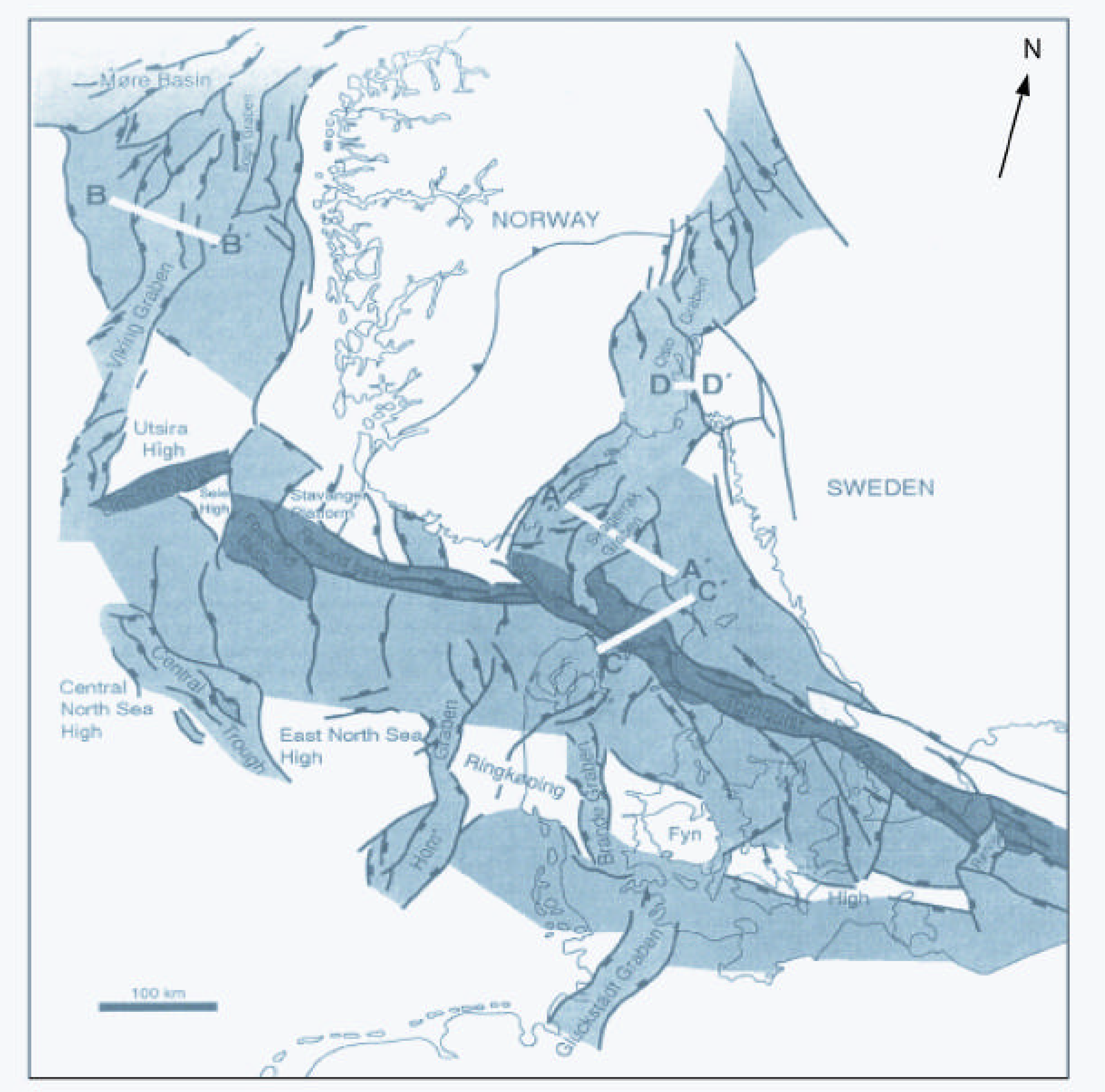


Figure 2.1: Simplified structural map of the Skagerak – Kattegat – northeastern North Sea area. The Tornquist – Teiseyre Line is marked dark grey (profile line C-C' and westward). From Olaussen, Larsen and Steel, 1994.

The northern border is poorly defined, but the Rift is confined northward by Caledonian thrust sheets and Late Pre-Cambrian Sparagmites. The North-Eastern area surrounding Brummundal (approximately 30 km to the north of the Oslo Rift) contains an eolian sandstone and a rhomb porphyry lava that by structure and age belong to the Oslo Rift. Even further to the NE, in

Sãrna in Sweden, there also exists an alkaline intrusive complex that in the same way belongs to the Rift (Larsen et al. 1995).

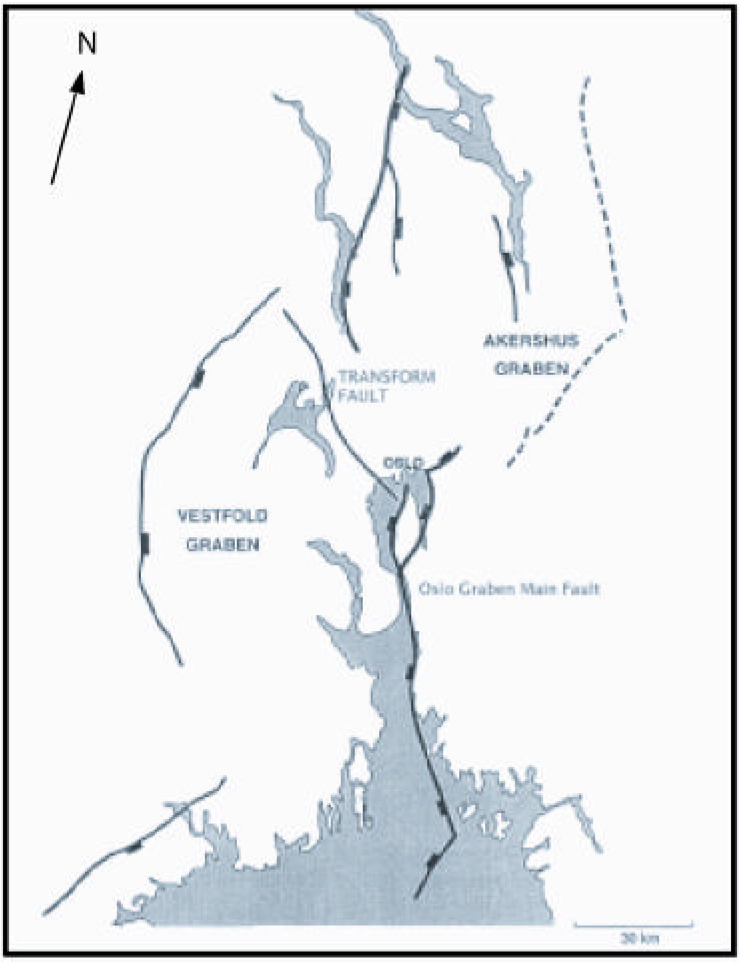


Figure 2.2: The graben structure and Transform fault of the Oslo Rift. Modified from Olaussen, Larsen and Steel, 1994.

2.3 Pre-Cambrian basement (545 mill. yrs. and older)

The Oslo Region is surrounded by pre-Cambrian basement to the East and West. This basement consists mainly of gneisses and amphibolites formed during the Sveco-Norvegic phase 1200 - ~850 million years ago. These rocks are formed by influence of high pressures and temperatures in the crust, altering their initial composition by metamorphosis.

The basement was consecutively eroded to a pene plain during the following 300 million years, before a series of trans- and regressions helped deposit the sedimentary rocks now comprising the Oslo Rift.

2.4 Early Palaeozoic sediments; Cambro-Silurian rocks (545-417 mill. yrs)

The Cambro-Silurian rocks of the Oslo Region constitute a 1000 – 1400 m thick sequence of marine and continental mud-, lime- and sandstones.
Within the Oslo Graben the Cambro-Silurian rocks are divided into five groups:

- Ringerike Group (late Silurian)
- Hole Group (Young early Silurian)
- Bærum Group (early Silurian)
- Oslo Group (Middle- to late Ordovicium)
- Røyken Group (Cambrian and early Ordovicium)

These groups are denoted The Oslo Super Group, and are sub-divided into formations of varying thickness =10m to =100m (Worsley et al. 1983, Owen et al. 1990). See Table 2.1 below for details.

The Oslo Super Group consists of a total of 10 members, including shales, nodular limestone, lime stones and sandy lime stones, and are all a part of the Oslo Graben and Rift structure. The Bærum group consists mainly of shales and limestones.

All, except the Ringeriks Group, were deposited in a marine environment on the Baltic side of the Iapetus Ocean. The Ringeriks Group was fluvially deposited in a fresh to brackish water environment in the foreland basin created during the Caledonian Orogeny.

2.4.1 Cambrian (545-495 mill. yrs)

During the Late Pre Cambrian, the sedimentation was influenced by a transgression from the north toward the south. The lack of Trilobites in the vicinity of Asker indicates a high energy regime in this area.
As the transgression continued into the Late Cambrian, the sedimentation was affected by the deeper water and anoxic conditions occur. This gave rise to black and organic rich shales; the Alum shales.

Table 2.1:

Stages 1-10 of The Oslo Graben. The Oslo Super Group. Modified from Oftedal (1981).

Age (mil. Yrs)	Group	Formation	Stage	Rock Types	Thickness by Oslo (in m)
Silurian (443-417)	Ringerike		10	Sandstone	500
	Hole	Steinsfjord	9	Lime-,clay- and marl	900
	“	Malmøy	8c	Lime- and clay stone	100-130
	Bærum	Skinnerbugt	8ab	Shale	
	“	Vik and Rytteråker	7	Limestone. Shale above.	115-150
	“	Solvik	6	Shale with inter layering of silt- and limestone	150-170
Ordovician (495-443)	Oslo	Langøy	5b	Sandy limestone	30
	“	Several	4c-d	Nodular limestones	~90
	“	“	4a-b	Shale, limestone and nodular limestone	190-235
	“	Vollen	4aß	Nodular limestone	
	“	Elnes	4aa	Shale	
Late Cam-brian	Røyken	Several	1-3	Shale, Alum shale, thin beds of limestone	105

2.4.2 Ordovician (495-443 mill. yrs)

The rocks from this period consist of shales and limestones deposited under fluctuating anoxic and ventilated conditions. Because of this, some of the shales are black whilst others have a light grey colour. These grey shales are different from the Alum shales of the Cambrian by a lower content of sulphur, uranium and vanadium (Owen et al. 1990).

By the end of Ordovicium the land around Oslo had risen and the sediments deposited where quartsittic sandstones and oolittic limestones.

2.4.3 Silurian (443-417 mill. yrs)

In the Early Silurian a transgression gave rise to the sedimentation and formation of limestones.

A new regression in the Mid-Silurian caused the formation of mud-cracks, and by the Late Silurian sedimentation was dominated by fluvial and deltaic sandy infill of the shallow marine sea (Worsley et al. 1983).

2.5 Late Palaeozoic sediments; Carboniferous and Permian rocks

2.5.1 Late Carboniferous (323-290 mill. yrs)

The oldest rocks related to the formation of the Oslo Graben include clay-, silt-, and sandstones as well as conglomerates belonging to the Asker Group (Dons and Gyøry 1967). These rocks are interpreted to be syn-rift sediments deposited during the formation of the Graben structure.

The Asker Group lies unconformably over the folded Cambro-Silurian sediments. This indicates that the underlying sedimentary rocks were deposited and uplifted, and the land eroded and was worn down before the Asker Group was deposited.

The rocks of the Asker Group have a maximum thickness of 70-80 m today and dating of the overlying B_1- basaltic lava reveals that they were deposited in the late Carboniferous (290 million years ago)(Sundvoll et al. 1990).
The rock assemblage consists of the following formations:

Table 2.2:

The rocks of the Asker group.

Age	Group	Formation	Rock Types	Thickness (in m)
Late Carboni - ferous (323-290)	Asker	Skaugum	Conglomerate, sandstone and mudstone	70-80
		Tanum	Quartz conglomerate, sandstone	
		Kolsås	Silt to sandy calcareous mudstone and shale	

The three formations of the Asker Group have been interpreted to mostly consist of continental deposits in a river dominated environment.

The contents of volcanic material increases upward through the Tanum and Skaugum Formations. The grains of the sandstones and conglomerates of the Skaugum Formation predominantly consist of material of volcanic origin, indicating that sedimentation continued until the formations were covered by the Permian plateau lavas.

2.5.2 Permian (290-248 mill. yrs)

The Cambrian to Late Carboniferous sedimentary rocks described above were covered by plateau lavas due to the volcanic activity in the Permian. During the final stages of rifting, lavas were deposited over vast areas. 15-18 calderas and related structures have been identified in the Oslo Region. The heterogeneous lava flows consist of Basalts (B_1 to B_3) and Rhomb Porphyry (RP_1 to RP_{30}) and constitute a thickness of up to 2 km depending on the location.

In connection to the deposition of the lavas, swarms of sills and dikes penetrate the sedimentary rocks underlying the volcanic cover (Sæther 1947).
There are four main types of dikes:

1. Mænaitt (Micro Syenite)
2. Diabase
3. Syenite Porphyry
4. Rhomb Porphyry

The dikes are exposed at the surface in several places and have a varying width on a centimetre to meter scale. Close to large intrusions the surrounding rock has been altered to Hornfels. Some of these intrusions are of great size and may be characterized as batholiths in volume and extension in the upper crust. The Drammen Granite is one example. Up to 60% of the area of the Oslo Region consists of batholiths of miscellaneous mineral composition. The varying mineral content depends on time of deposition and location within the Rift.

The time scale used for the determination of the ages in the section above is from Gradstein and Ogg (1996).

2.5.3 Loose sediments

Norway has during the past 2.5 million years been totally covered in ice for long periods of time. The sediments found in the Oslo Region today consist mainly of marine and glasifluvial deposits from the glacial episode, approximately 11000-12000 years ago.
As the ice retreated northward there were breaks in the retreat and the front of the glacier paused, giving rise to large deposits of different till masses, sand, silt and clay.

Generally, the sediments overlying the Cambro-Silurian rocks within the Oslo Region today consist of marine deposits of silt and clay. The upper marine boundary is located at approximately 220 m a.s.l. Along the transition between bedrock and sediments, the deposit contains large amounts of coarser and more permeable masses (sand and gravel). Lenses of loose till masses occur in today's landscape as remnants from the previous ice age. The thickness of these sediments varies between 0 and 20m and the largest variances are observed in connection with the Cambro-Silurian sedimentary rocks (Norconsult 1999).

2.6 Structural Geology of the Oslo Rift

Although the Cambro-Silurian rocks of the Oslo Graben were influenced by the Permian rifting, many of their structural features are due to the development of the Caledonian Orogen (420-400 mill. yrs) in the Late Silurian - Early Devonian, when the rocks experienced compressional forces from the NW. In subsequent chapters this orientation will also be referred to as the direction of the major principal stress (s_1).
The units were deformed and altered as they were transported toward the SSE and now experience folding with a slightly dipping axis orientated ENE or WSW. In subsequent chapters this orientation will be referred to as the direction of the minor principal stress (s_3).

The Cambro-Silurian units in the Oslo Graben consist of relatively thick sequences deformed by thrusting over a basal glide plane of Alum Shale. The rocks consist of relatively thick incompetent shales often containing bands of limestone and nodular limestone, and some thinner layers of more competent lime- and sandstone. These main rock types will therefore react differently to deformation.

The shortening of the pack is approximately 60% and includes both thrusting and folding. The outcome being that the more competent layers have an elliptical, often jointed appearance, while the incompetent layers have a tight and sharp geometry.

2.6.1 Joints, faults and cleavage

Joints

A series of fault activities during late Caledonian and Permian times has had its profound impact on the rock assemblage. During the Caledonian Orogen, the thrusting of large sheets of rock from the NW resulted in the deformation of the Cambro-Silurian rocks of the Oslo Region through folding and faulting. Even though the large scale deformation occurred west of the Oslo Rift, the rocks of this region show clear evidence of the forces at hand.

Permian faults and joints of all magnitudes occur throughout the Oslo Graben. The dominating orientation is steeply dipping NW-SE to NNW-SSE, consistent with the dominating joint-orientation in the region (Ramberg et al. 1977, Larsen et al. 1995). See Figure 2.3 below for main orientations.

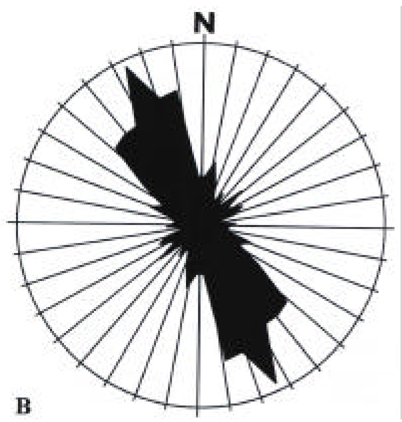


Figure 2.3:
Rose diagram of joints and faults.
Main orientation NNW-SSE
Modified from Nordgulen et al.(1998).

Some of these NNW-SSE faults have displacements large enough to displace bed plane boundaries, and will constitute zones of poor rock quality. The trace of the fault may consist of a several meter wide zone of altered rock and clay filling (Løset 1981b) and is in some cases accompanied by an intrusive dike strike parallel to the fault.
Several joints, especially within the sedimentary sequences, have a filling of Calcite, Chlorite or clay.
Joints parallel to bed plane layering occur especially at the boundary between layers with different mechanical properties. These joints may be water bearing (Løset, 1981b).

Cleavage

Shales and shaly sequences of the nodular limestone contain smaller plane joints parallel to the bed planes. This is believed to be a *compaction cleavage* (Nordgulen et al. 1998) resulting in partially heavy fracturing when exposed to compressive forces.
This cleavage is parallel or has a small angle to the strike of the layering and therefore has the same orientation as the bed plane parallel fracturing.

The Cambro-Silurian rocks of the Oslo Graben in general show a *young cleavage*. In certain shale horizons this cleavage is the source of heavy fracturing; in others it has overprinted all initial structures leaving the cleavage as the dominating structure.

Layers rich in limestone show a more sporadic *cleavage due to pressure solution*, but this cleavage does not give room for joint planes in the rock (Nordgulen et al. 1998).

In shaly horizons with joints developed along layering and cleavage, the rock will easily split into pencil shaped fractions. The combination of joints and cleavage with varying orientation will therefore have a profound impact on the mechanical properties of the rock.

2.6.2 Zones of weakness

Faulted and thrusted rocks also show fracturing but not necessarily because of the competence contrast to the surrounding rock. Most joint- and fault zones have a tectonic origin.
Fault zones tend to have a specific design where different areas experience heavier fracturing than others. These areas make up a joint lineament consisting of zones of differentiated fracturing depending on the distance from the core of the fault. The architecture of such a lineament can be described as that of Braathen and Gabrielsen (1998):

The fault core

> The core of the fault constitutes the central segment of a joint zone. The zone is usually a few cm to 20 m wide. This zone consists predominantly of joints that are sub-parallel to the lineament and often contain fault rocks.
> The fault core includes zones A and B, which are described below.

The damage zone

The damage zone is usually 5 to 50 m wide. The joints are either orientated sub-parallel to the lineament or consist of two sets of joints with a 60° separation. This zone includes zones C and D, which are described below.

The transition zone

The transition zone constitutes the outermost section of the lineament. Beyond this zone the surrounding rock is not influenced by the joint deformation. The orientation of joints within this zone is highly variable, but there is a tendency showing that the joints are orientated 20 - 40° to the lineament. This zone may be up to 200 m wide and includes zone E, which is described below.

A characteristic feature for the zones A-E are that they distribute in a specific pattern around the lineament. One zone may in many cases gradually pass on to another or vanish. Another common feature is the overlapping of two zones so that several zones create a joint complex.

Zone A

constitutes the core of the lineament and is the section of lineament consisting of fault rocks. The zone varies in width within a mm to km scale all depending on the size of and relative displacement along the fault. This zone often shows secondary mineralization.

The zone is not always developed and only exists where a minimum of displacement has taken place.

Zone B

is characterized by a high concentration of short, mainly parallel joints. The joints often form a small angle to the lineament. The width of the zone is usually only a few meters wide, and the distance between the joints varies on a mm to 10 cm scale.

Zones A and B together constitute the centre of the lineament. In the cases where Zone A is scarce or non-existing, Zone B will act as the lineament core.

Zone C

is characterized by large, parallel joint surfaces with angles between 5 and 20° to the lineament. Distance between joints is usually 10-50 cm and the zone generally occurs as a 5-50m wide zone on either side of Zone B. In the cases where Zones A and B are scarce or non-existing, Zone C will act as the lineament core.

Zone D

occurs on either side of Zone C and consists of two sets of long joints symmetrical about the lineament axis. The angle between the lineament axis and strike of the joints is usually approximately 30° giving a separation of 60° between the sets.
The zone is usually 5-10 m wide.

Zone E

occurs on either side of Zone D making up the outer limits of the lineament. The zone varies in thicknesses between 10-200 m. There exists a slight dominance of joints orientated less than 40° to the lineament.

This type of lineament is expected to exist in the Oslo Region and implicit along the trace of the tunnel.

2.6.3 Folded rocks

Generally, the geometry of folds will be controlled by the thickness- and competence of the rock in addition to the relation between the thickness of the layers, contrasts in competence within the unit and the total degree of shortening of the pack.
Strong and competent bed planes show a tendency to joint as they fold, due to the fact that their compressional strength is exceeded during compression. Thin and less competent layers behave in a more ductile fashion when exposed to the same compressive forces as more competent rocks.

The folds are faulted reversely with an ENE-WSW orientation and a slight NW dip. Experience from the VEAS Tunnel indicates that these faults may contain several decimetres thick clay zones (Løset 1981a). In general, many of the fold bends are replaced by a series of joints and faults joined to make a weakness zone running parallel to the strike. The weakness zones may partly be open and constitute water channels.
The joints often appear as bed-plane-joints; joints parallel to the bed planes. These joints especially occur between layers of different lithologies, but also exist within a homogeneous layer. The formation of joints in connection to folding also appears as cleavage joints. See

description of cleavage in Section 2.5.1 for further details.

2.6.4 Intrusive dikes

A large number of intrusive dikes run strike-parallel the bedrock layering (NE-SW).
Most of these dikes seem to be near vertical and their strike is near parallel to that of the surrounding rock. Figure 2.4 below shows main orientations of dikes mapped during the pre-investigation phase of the project.

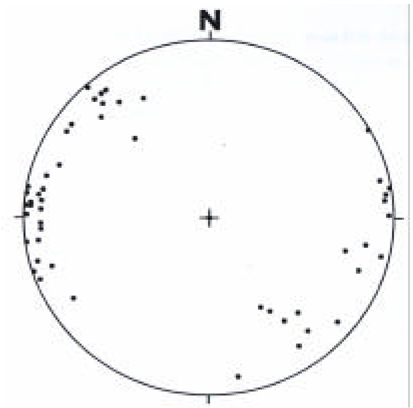


Figure 2.4:
Stereo projection of poles to intrusive dikes. Main orientation NE-SW. Modified from Nordgulen et al. (1998).

There are several examples showing that the dikes tend to joint heavily when they appear close to faults, and the dikes also tend to joint more heavily than the surrounding bed rock when subjected to tectonic forces.

The degree of fracturing varies, but in most cases the fracturing is most intense along the border to the surrounding formations. The explanation for this is that the dike fissures during cooling and that the dikes have a different competence than the penetrated rock.
Open joints along these borders are exposed to water leakage. The hazard of leakage increases as the dikes cross a fault zone.

2.7 Geology along the JA1 tunnel

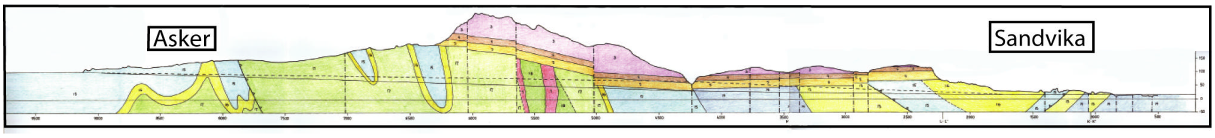


Figure 2.5: Profile of the JA1 and JA2 tunnels (Norconsult 1999). Legend is the same as for Figure 6.13, Chapter 6.

Figure 2.5 above portrays a geologic cross section of the geology along the traces of the JA1 and JA2 tunnels, based on pre-investigation data and mapping. The JA1 Skaugum tunnel is to the left and the JA2 Tanum tunnel to the right. As seen from this profile, the Cambro-Silurian rocks are folded, faulted and intercepted by dikes. The Asker group lies un-conformably over the sedimentary rocks of the Oslo and Bærum groups.

Although the geology of the Oslo Region clearly includes the JA2 tunnel, there will not be a detailed description of the geology along its trace. The reason for this, is that this thesis does not include any data from the tunnel beyond that of the preliminary reports made in connection with the pre-investigations.

Along the trace of the JA1- tunnel the dominating rock-types include the 2nd to 8th stages of the Cambro-Silurian Oslo Group, and the Silurian members of the Bærum Group. These groups consist of alternating shale, nodular limestone, limestone and sandy limestone.

The rocks are, as in the description of the Oslo Region above, folded, faulted and thrusted in the same fashion as the rest of the strata within the graben structure, with predominantly steeply dipping bed planes to the NNW.

Most of the lithologies along the trace of the tunnel show layer-parallel jointing.
Large faults running strike parallel and NS have been encountered mostly in the tunnel directed toward Hønsveien. Some of them indicate B and C zone fracturing to either side of the fault core. Strike parallel faults accompany fold bends and give rise to zones of altered rock and clay infill.

The rocks are infected with smaller joints orientated steeply to the NW-SE to NNW-SSE. These joints tend to be mapped uniquely as they often have calcite, chlorite or clay mineral infill.

There are no large areas of flat laying strata recorded to cause increased hazard during the work in the tunnel.

A number of dikes cross the trace of the tunnel. These dikes have not been differentiated well during mapping, so there rests an uncertainty to the type of dikes that have been registered along the tunnel profile. Most of the dikes are accompanied by faults running parallel to the strike of the dike and thereby contributing to a wider section of poor rock conditions.

The overlying loose sediments are found especially on the southern side of Skaugumåsen and in the vicinity of Jansløkka School.

Chapter 3
Hydro- and engineering geology

3.1 Hydro geology

The water in rock masses is an integrated part of the hydrologic cycle as demonstrated in figure 3.1. Groundwater may travel considerable distances through a rock mass and it is therefore important to consider the regional geology and the overall groundwater pattern when potential water problems are analyzed.

Groundwater, by definition, is the freely moving water that occurs below the water table in fully saturated geologic formations, either it being hard rock or unconsolidated sediments. This water represents the major part of subsurface water.

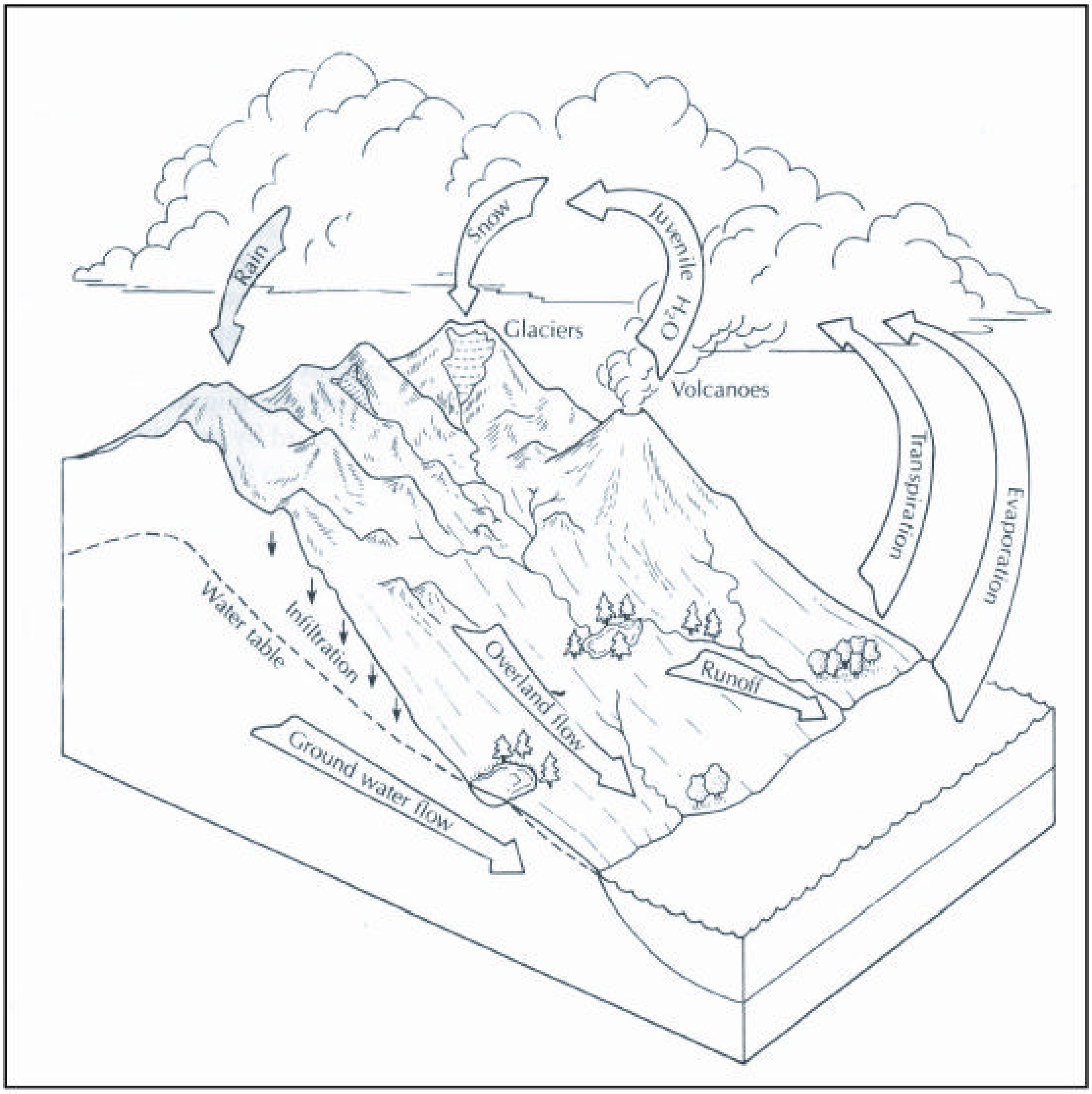


Figure 3.1: The hydrologic cycle. From Fetter, 1994.

Groundwater flows from a higher to a lower energy potential. This is demonstrated by Darcy's law:

$$q = \frac{Q}{A} = -K\frac{(h_1 - h_2)}{\Delta l} = -K\frac{\partial h}{\partial l} \quad \text{(Domenico and Schwartz, 1990).}$$

where

$\frac{Q}{A}$ = volumetric flow rate per unit surface area

$\frac{(h_1 - h_2)}{\Delta l}$ = hydraulic gradient (i)

An excavated underground opening acts as a drain to the surrounding rocks as the energy potential in the excavation is zero and the surrounding rock is positively different from zero. The leakage into a tunnel (q) is mainly determined by the hydraulic conductivity (K) of the rock mass, the head of water (h) and to some extent disturbances caused by excavation, and the tunnel cross section (r) by the following relationship:

$$q = \frac{2pKh}{2{,}3\log[2h/r]} \quad \text{(Freeze and Cherry, 1979).}$$

where:

q = leakage (m3/m/s)

K = hydraulic conductivity or permeability around the tunnel (m/s)

h = distance from tunnel to groundwater table

r = tunnel radius (m)

The hydraulic conductivity (K), often referred to as permeability or the coefficient of permeability, is the rate at which groundwater flows through a unit area of aquifer under a unit hydraulic gradient. It has dimensions of velocity (L/T) and is a proportionality constant.

The relation between hydraulic conductivity and intrinsic permeability follows the equation:

$$K = \frac{k r_w g}{m} \quad \text{(Freeze and Cherry, 1979).}$$

where

K = hydraulic conductivity or permeability

k = intrinsic permeability

$?_w$ = density of water

g = acceleration of gravity

µ = viscosity of the fluid

For flow in fractured rocks, Darcy's law takes the aperture and width of the fracture into account. Using the parallel-plate theory, one gets:

$$Q = \frac{r_w g b^2}{12m}(bw)\frac{\partial h}{\partial L} \qquad \text{(Domenico and Schwartz, 1990).}$$

where

Q = volumetric flow rate

$?_w$ = the density of water

g = the gravitational acceleration

µ = viscosity of the fluid

b = aperture opening (assumed constant along the fracture)

w = fracture width perpendicular to the direction of flow

$\frac{\partial h}{\partial L}$ = the gradient in the flow direction

3.2 Hydrogeology along the JA1 and JA2 tunnels

The area situated between Jong and Asker (including the JA1 and JA2 tunnels) consists of three main hydro-stratigraphic units:

The Cambro-Silurian sedimentary rocks

The Asker group and over lying lavas

Unconsolidated sediments

The rocks themselves have such low permeability values that they are generally considered impermeable. For tunnels in non-fractured rock leakage would present little concern. However, as the rock mass is frequently highly fractured, the permeability of the cracks give the rock mass a secondary porosity, much higher conductivity, and increased flow rate, implying a need for control of the incoming water to the tunnel. Table 3.1 below gives permeability values for rock masses affected by the construction work.

Geological unit	Permeability (K)
Rhomb Porphyry	$4.0x10^{-6}$m/s *
Basalts	$1.4x10^{-6}$-$2.0x10^{-5}$m/s*
Asker Group	$3.0x10^{-7}$-$4.0x10^{-6}$m/s
Cambrian-Silurian	$3.0x10^{-7}$-$2.0x10^{-6}$ *
Fault	$1.0x10^{-7}$m/s *

Table 3.1 Permeability (K) estimates from slug tests. *From Marques, 2003. * values taken from Norconsult,2000a, estimated from water loss measurements.*

Permeabilities (K) of these rocks have been estimated based on water loss/draw-down measurements using the Lugeon test (Norconsult, 2000a) and from slug- and pumping tests (Marques, 2003). 1L (Lugeon) corresponds approximately to a rock mass permeability of 10^{-7}m/s.

Although the JA1 and JA2 tunnels run mostly through the Cambro-Silurian sedimentary rocks of the Oslo Super Group, small sections of JA1 and larger sections of JA2 are crossed by dikes. The JA2-tunnel is also thought to run through lower units of the Asker Group in the vicinity of Lagerudbekken.

In the report from Norconsult (2000a) the estimated leakage into the un-grouted tunnel where it crosses zones of weakness or dikes shows a permeability of $5.0x10^{-6}$ m/s. Pumping tests from Åstadbakken 60 along the JA2 tunnel show a hydraulic conductivity of $K = 4.6x10^{-6}$ m/s (Marques, 2003). Norconsult predicts that these values of K correspond to an inflow rate (q) of 1800-3600 l/min/100m of tunnel.

3.3 Water inflow and grouting

3.3.1 Inflow patterns

The general impression from observed leakage features is that most leakages in rocks are concentrated in local channel-like veins. Such channel-like veins may be found at the intersection between fracture systems in the rock or be a result of joint roughness and relative displacement along the fractures. In addition it may be the result of erosion or chemical solution of joint filling materials (Karlsrud 2002).

Experience from the VEAS tunnel (Løset 1981a) indicates that the greatest leakages in the Cambro-Silurian sedimentary rock mass are caused by highly fractured dikes. Approximately half of the dikes are more water bearing than the surrounding rock. In addition, the rocks comprising the B- and C zones of a fault lineament (Braathen and Gabrielsen, 1998) and fold hinges (Løset, 1981b) may experience high permeability compared to the surrounding rock.

3.3.2 Water inflow restrictions

To prevent subsidence damage to structures founded on soft sediments like clay above the tunnel or the wilting of vegetation in sensitive nature reserves, there are specified strict criteria for water tightness in the tunnels in the Oslo region (Løset 1991).
Even relatively small ground water leakage into a tunnel underlying or located close to soft deposits may rapidly reduce the pore pressure at the clay-rock interface. This will then initiate a consolidation process in the clay deposit gradually progressing upward through the deposit (Løset 1991). As the groundwater table is lowered beyond the natural seasonal variation, the water may not be accessible to plants, resulting in drought in the nature reserve.

A result from the pre-investigations of the project is the estimates of water inflow restrictions along the trace of the tunnel. Because of the problems that may occur in connection with subsidence of buildings on the surface or the sensibility of the vegetation to a lowering of the groundwater table, restrictions are made to the permitted inflow rates of water to the tunnel. The restriction is given in allowable leakage per minute per 100 m of tunnel length, i.e l/min/100 m.
The work done in connection with the strategy for ensuring water tightness takes into account:

- Ground water level above the tunnel and natural variation through time.
- Natural infiltration of water to the aquifer.
- Hydrogeologic boundaries.
- The heterogeneity of the aquifer and the understanding of preferential flow patterns.
- The relation between rate of leakage, permeability of the grout curtain and permeability of the aquifer. (Norconsult, 2000a).

The different sections of the surface above the tunnel are therefore categorized as follows:

CLASSIFICATION OF SUBSIDENCE CONTINGENCIES			
Subsidence class		**Thickness of loose sediments (clay)**	**Subsidence**
I	Small	< 5 m	< 40 mm
II	Moderate	5 – 10 m	30 – 80 mm
III	Large	>10 m	> 80 mm

Table 3.2 Classification of subsidence contingencies*(from Norconsult, 2000). All values are within a 400 – 500 m influence area of the tunnel.*

Table 3.3 Classification of vulnerability of nature reserves *(from Norconsult, 2000). Relevant for locations within a 400 – 500 m influence distance from the tunnel.*

CLASSIFICATION OF VULNERABILITY OF NATURE RESERVES		
Sensibility class		**Definition**
i	Small	Groundwater table > 2 m below surface but in contact with loose sediments. The vegetation is only dependent on groundwater for short periods of time.
ii	Moderate	Groundwater table 0.5 – 2 m below surface. The vegetation is dependent on groundwater during periods of the growth season.
iii	Large	Groundwater table < 0.5 m below surface. The vegetation is dependent on groundwater during long periods of the growth season.

On the basis of the tables above and the mapping and laboratory investigations of the loose sediments, water inflow restrictions have been applied to the tunnel according to Table 3.4.

Table 3.4 Water inflow classification *(from Norconsult, 2000).*

		Water inflow class		
		Class 3	*Class 2*	*Class 1*
Water inflow, upper limit (l/min/100m of tunnel)		<4	4-8	8-16
Primary holes for injection	No. of holes	16	12	8
	Length of holes	24	28	32
Overlapping of grout curtains (m)		7	7	7
Water loss limit (Lugeon)		0,3	0,6	1,2
Limit for increasing no. of holes for injection	Outflow (l/min)	0,6	1,2	2,4
	Water loss (Lugeon)	0,3	0,6	1,2
	Mass entry (kg/m)	12	16	20

As the lower part of Table 3.4 indicates, additional holes in the grout curtain need to be added as certain limits for outflow, water loss and mass entry are exceeded.

For the JA1 tunnel the water inflow classes are distributed as follows:

- Class 3 (<4 l/min/100m) : 300 m corresponding to 8% of the total length of the tunnel.
- Class 2 (4-8 l/min/100m) : 2730 m corresponding to 75% of the total length of the tunnel.
- Class 1 (8-16 l/min/100m) : 600 m corresponding to 17% of the total length of the tunnel.

3.3.3 Grouting

Water leakages into underground excavations can greatly affect working conditions and total costs of the project. In extreme cases several months of delay in construction may be the result.

The traditional purpose of grouting in connection with tunnel excavation has been to avoid major water inflows to reduce the amount of water that has to be pumped out of the tunnel system both during and after construction. In many cases grouting has only been considered as a contingency measure, used to solve a problem only after a problem of water inflow has occurred (Roald et al. 2002). To avoid major inflows of water it is of great importance to effectively grout the un-excavated rock ahead of the working face of the tunnel. By doing this the effective permeability of the rock is reduced thereby reducing the rate and amount of water that would otherwise flow freely into the excavation.

The overall result from an effective pre-grouting programme will be reduced rock mass permeability, increased deformation modulus and increased seismic velocities, and reduced tunnel displacement and rock support requirements when tunnelling (Roald et al. 2002). An important bi-product of the grouting is the strengthening and stability effect (Barton et al. 2002).

To be able to meet the water inflow criteria specified in Section 3.2.2, a near impermeable grout curtain needs to be installed, surrounding the excavation. See Figure 3.2 below and 3.3 in Section 3.3.4 for illustrations.

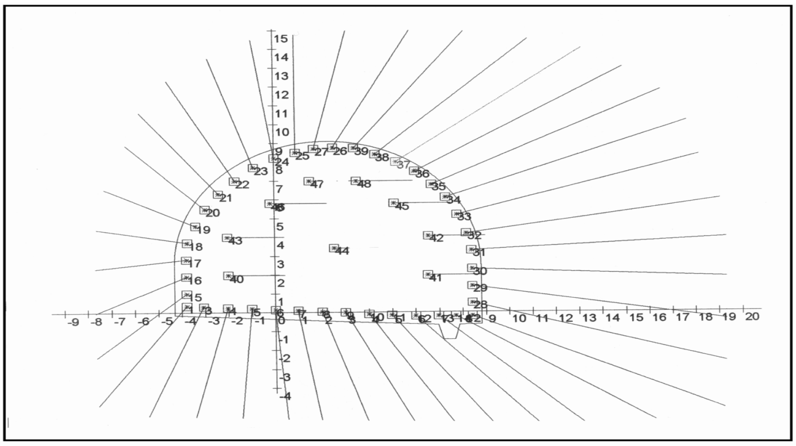


Figure 3.2 The installation of the grout curtain is done by drilling long, peripheral holes around the planned tunnel opening and subsequently injecting the holes with special cement. View is directly toward the tunnel face. Modified from Mika, 2003. Out print of drilling plan from the computer on their Tamrock drilling machine for grout curtain installation.

An effective pre-grouting programme should ideally decrease the permeability of the rock due to fractures by a factor of 10^2. The permeability of the grouted tunnel should be ~$1.5\cdot10^{-9}$ – $7\cdot10^{-9}$ m/s to fulfil the water tightness criteria for a tunnel in a populated area above compressible sediments (Johansen 2002).

The estimations from Marques (2003) give permeability values of a grout curtain 1m thick:

$K_G = 5.0x10^{-11}$ m/s for an inflow rate of 1.2 l/min/100m

$K_G = 1.0x10^{-10}$ m/s for an inflow rate of 2.3 l/min/100m

$K_G = 5.5x10^{-9}$ m/s for an inflow rate of 4.3 l/min/100m

3.3.4 Grouting scheme

A grout curtain is a near impermeable barrier of industrial or micro cement injected under pressure into the rock surrounding an excavation. For tunnels, this is done by drilling 20-50 peripheral holes with a certain angle from the contour of the working face into the un-excavated rock, and subsequently filling the discontinuities intersecting the drill hole (figure 3.3). Table 3.4 gives an overview of the number of drill holes comprising the curtain, the length of the curtain, the size of the overlap and the number of blasts before the next curtain is installed.

Figure 3.4 gives details of the procedures connected with installing the curtain.

The number and length of the holes depends on the water inflow criteria and rock quality at the specific site.

In practice, the execution of pre-grouting has to be adjusted to the conditions at the site and on experience which has to be acquired as construction proceeds.

The number of injection rounds may vary, as will the grout take, with the structure and characteristics of the rock mass. Figure 3.5 refers to grouting procedures and corresponding pre-grouting types x, xx, and xxx. The pre-grouting types are according to Norconsult, 2000:

- Type x ½ round of industrial cement and ½ round of micro cement in average.
- Type xx 1 round of industrial cement and 1 round of micro cement in average.
- Type xxx 1 round of industrial cement and 2 rounds of micro cement in average.

Overlapping

In most new tunnels in Norway, the grout curtains overlap each other to ensure a water inflow minimum and maximum stability. The length of the overlap varies depending on the geological conditions and water inflow criteria at the site.

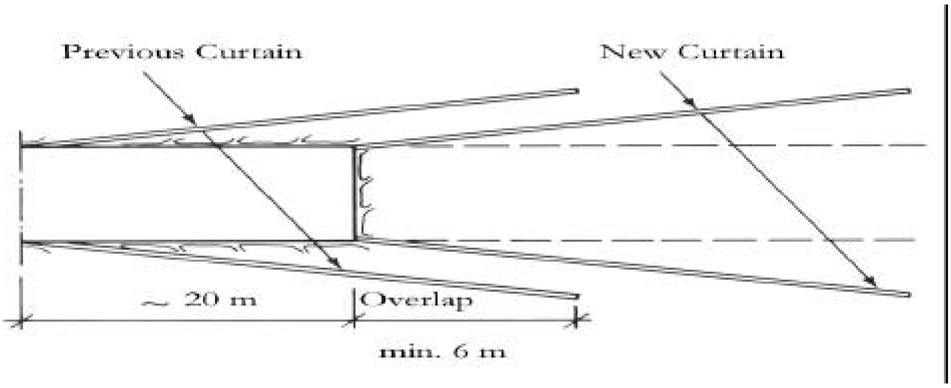


Figure 3.3: The principle of constructing a grout curtain (from Nilsen and Thidemann, 1993). For the JA1 tunnel JBV operates with a 7 m overlap and curtains of up to 48 drill holes along some sections of the tunnel trace.

Grouting pressure

For the grout to effectively penetrate and fill the discontinuities intersecting the drill hole, a certain pressure needs to be obtained during injection. The aperture and roughness of the fractures and cracks in addition to the maximum grain size and viscosity of the grout are of great significance. The pressure with which the grout is injected is also an important parameter.

The pressures used during construction of the JA1 and JA2 tunnels are shown in table 3.5.

Drill hole emplacement	**Surface to tunnel depth**	
	<10 m	>10 m
Roof	30 bar	50 bar
Walls and sole	50 bar	70 bar

***Table 3.5** Injection pressures (from Norconsult, 2000b).*

Pressure problems

If the pressure of the injected fluid is too high, *hydraulic fracturing* may occur.
Goodman (1989) expresses it this way for a vertical drill hole:

$$3s_{h,min} - s_{h,max} - p_{c1} = -T_0$$

where

$s_{h,min}$ = smallest horizontal compressive stress, $s_{h,max}$ = largest horizontal compressive stress
p_{c1} = down hole water pressure when the fracture opens up, T_0 = tensile strength of the rock.

This equation is based on the assumption that penetration of water into the pores of the rock has little or no effect on the stresses. Using the "Kirsch solution" the initial stresses at the point of fracture (p_{c1}) may be calculated. See Figure 3.4 below for details.

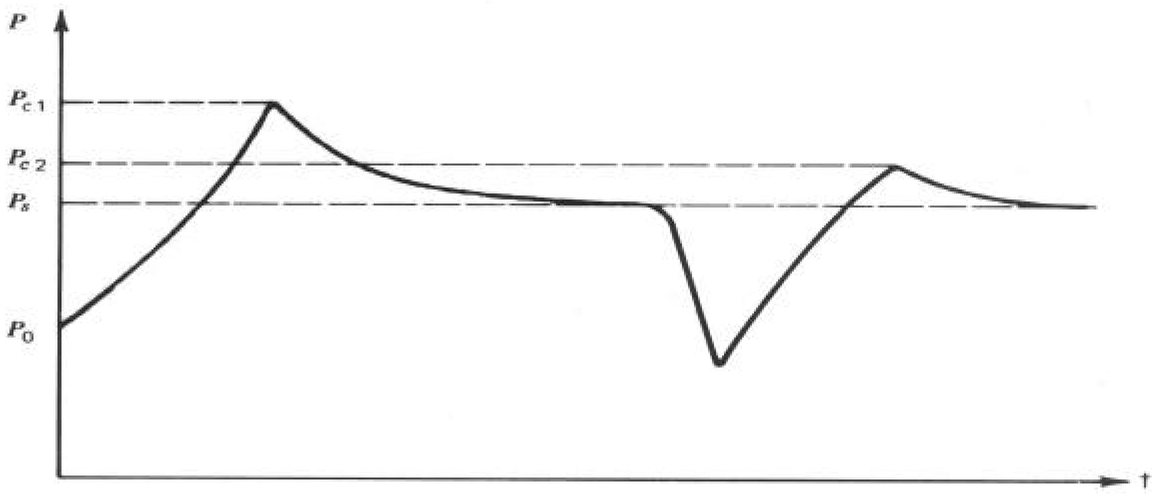


Figure 3.4: Pressure versus time data. Hydraulic fracturing occurs at p_{c1} for initial conditions and later at p_{c2} for re-loading conditions (from Goodman, 1989).

When the networks of fractures above the tunnel are connected upward through the zone of weathered rock, the cracks may act as conducts and grout may extrude on the surface. It is therefore important to adjust the grouting pressure accordingly as construction proceeds.

Viscosity of the grout

The type of grout used depends on the pressures obtained during injection. Usually the initial grout is a micro cement mixture to achieve deep penetration into narrow joints. When and if the required pressure is not obtained after a certain grout take, a more viscous grout recipe is applied.

Three main recipes used are as follows:

Recipe 1: Micro cement with added super-plasticizer, containing a maximum grain size of approximately 15 micron. The water/cement ratio should be 0.6 – 1.0.

Recipe 2: Industrial cement with added super-plasticizer. The water/cement ratio should be 0.6 – 1.2.

Recipe 3: Industrial cement with added sand and an expanding substance. The water/cement ratio is adjusted according to the added sand fraction to increase pumpability.

An accelerator may be added to speed up the process of hardening. Continuously during construction of the JA1 tunnel, Thermax has been used as an accelerator.

3.4 Ground water monitoring

The criteria for water tightness (impermeability) of the tunnel are set by the need to maintain a stable groundwater table and pore pressure in the loose sediments above bedrock. If the pore pressure drops below a certain limit, this will initiate a consolidation process of the sediments, causing possible settlement damage to the buildings and installations founded on them, and damage to the vegetation within the influence area.

As mentioned in Section 1.4.5, to ensure that the groundwater table is stable within a certain natural water level variation inside the influence area of the tunnel, both existing private wells and new observation wells have been equipped with sensors to register any changes in the water table. Water infiltration wells are installed consecutively along the trace of the tunnel whenever the water table drops below a certain limit. These wells are used to pump water back into the system when necessary, ensuring stability in the groundwater level at any given time and location.

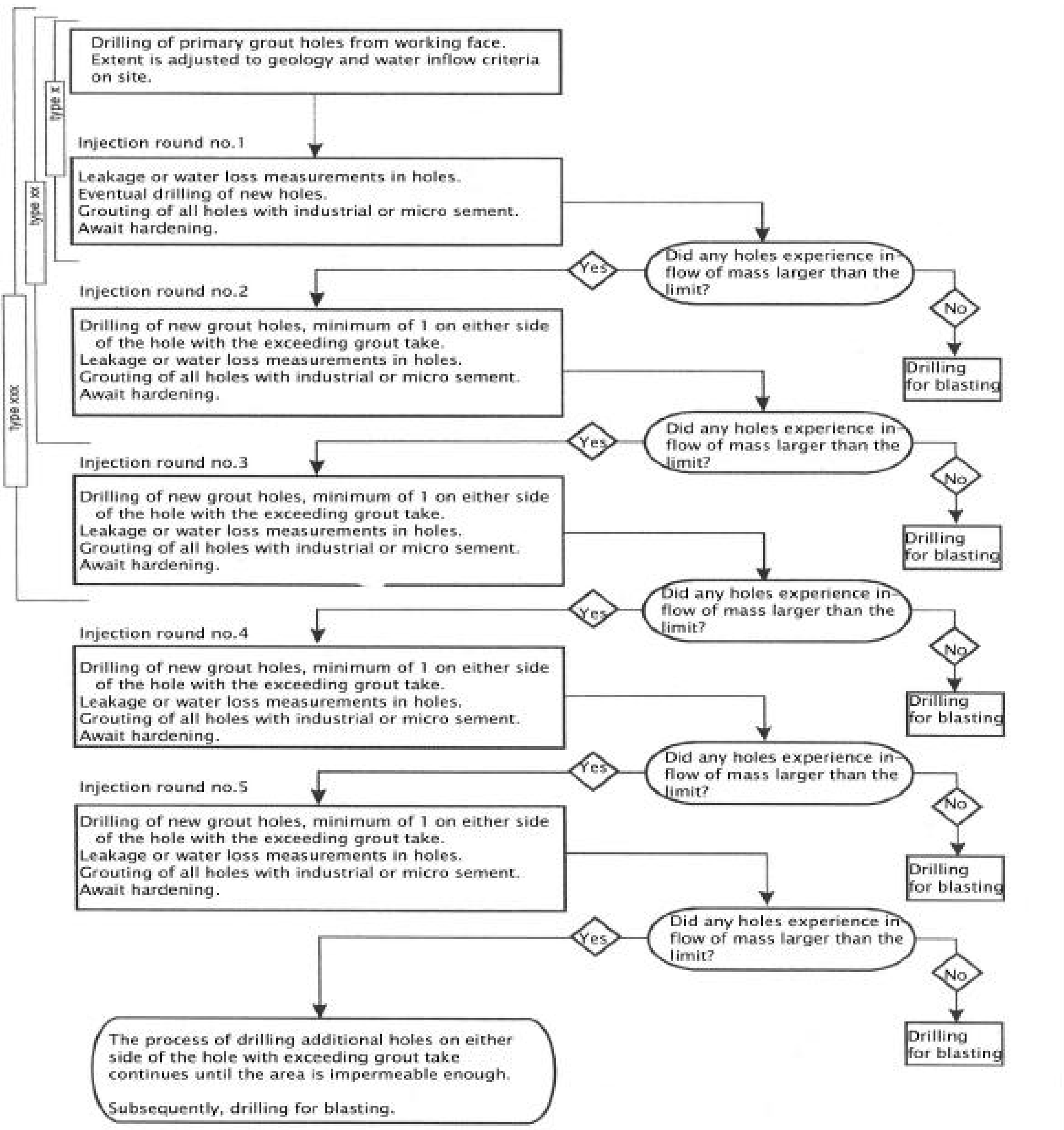


Figure 3.5: Principles for conducting pre-grouting. The extent of grouting depends on which water inflow class is relevant for the tunnel at the site (From Norconsult, 2000).

Chapter 4

The Q-system for rock mass classification

The reader of this chapter may feel that the description of the Q-system, its parameters and its general application is quite detailed. This is done deliberately to give the basis for understanding the parameters involved in relation to the results of Chapter 6 and conclusions of Chapter 7.

4.1 Application in general

The Q-system is a method for classifying rock masses with respect to the stability of tunnels and underground excavations and for dimensioning supporting measures during and after construction. The system is also used prior to construction as a part of the pre-investigations. The Q-system was developed at The Norwegian Geotechnical Institute (NGI) in 1974 by Barton et al. The system has been updated since then, in 1993 by Grimstad and Barton, and in 2002 by Barton. It now contains over 1000 examples from existing tunnels and excavations. With this method the engineer is guided in his/her choice of safeguarding the tunnel.

The Q-value includes six parameters and gives a description of the rock mass. The Q-value indicates a certain condition of rock mass stability, hence indicates required support measure needed to stabilize the underground excavation:

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

(Barton et al. 1974).

The higher the Q-value, the better the rock mass stability. The different parameters are defined in Section 4.2.

4.2 The parameters of the Q-system

4.2.1 Degree of fracturing (RQD/J_n)

The degree of fracturing or size of the individual rock blocks will be determined by the joint pattern, i.e. the orientation and distance between the joints. Barton et al. (1974) write that the RQD/J_n ratio is a measure of the general structure of the rock and a rough estimate of block size.

Most localities have two to four joint orientations that occur systematically. Joints that occur parallel or sub-parallel constitute a joint set and their internal distance will be characteristic for that particular set. In cases where the distance between the joints is distinctly smaller than usual, the joints constitute a joint zone.

In general, the stability conditions will decrease as the number of sets and the internal distance between joints within the set, increases (Løset 1997).

RQD: Rock Quality Designation

The length of all segments in a drill core longer than 10 cm in % of the total length of the core gives the RQD value. Only non-drilling related cracks are considered. The lowest RQD-value is 10. When lower values are encountered, the value is rounded up to 10.

RQD_{min} = 10; RQD_{max}= 100.

Where a core is not available, the RQD-value can be estimated from the number of cracks per m^3 on a given surface by

$$RQD = 115 – 3,3J_v \quad \text{(Palmstrøm, 1982).}$$

where J_v is “joint volumetric count”.

The latter method is very applicable in underground excavations as a 3D overview is easily obtained by studying the roof and walls of the excavation.

J_n: Number of sets of discontinuities

This parameter describes the number of dominating sets of discontinuities in a volume of rock. Discontinuities are for all practical reasons the same as joints.

A set of joints is characterized by sub-parallel joints that occur with regular spacing. The length of the joints must be taken into consideration as must random cracks that may add to the total instability of a block (Løset, 1997). The higher the J_n-value, the more joint sets occur in the rock mass.

$J_{n\ max}$ = 20 for crushed rock; $J_{n\ min}$ = 0.5 for massive rock.

The J_n-value is estimated by means of Table A2 in Figure 4.2.

For tunnel portals the J_n-value should be multiplied by 2, and by 3 for intersecting tunnels.

4.2.2 Frictional conditions along joints (J_r/J_a)

This ratio describes the shear strength of the joint surface.

Frictional conditions in hard rock are crucial when considering the deformation of the rock mass, as most deformation will occur as displacement along joints and their surfaces.

As differential stresses increase, the Mohr circle touches the line of frictional slip along pre-existing joints before that of shear rupture of intact rock, initiating deformation along pre-existing joints prior to initiation of new cracks in intact rock (Engelder 1993).

Friction is determined by the properties of the joints including the mineral filling they may contain. The more asperities and less soft filling the cracks consist of, the more favourable in terms of rock mass stability. In the opposite case, a thick clay filling reduces the friction causing instability in the rock mass (Løset 1997).

The correlation between the J_r/J_a-ratio and the angle of internal friction for the joint surface is given by Barton et al. 1974 as

$$\varphi = \tan^{-1}(J_r/J_a).$$

J_r: Roughness of discontinuities

A non-planar joint will give rise to a higher friction value for the joint than a planar joint, and thereby increasing rock mass stability. The roughness of a joint is valued by observing small- and large scale variations in roughness along the joint surface. Small scale roughness may be estimated by sliding a finger across the surface.

Large scale roughness may be estimated by placing a ruler across the surface and observing the amplitudes of the asperities, and is described as undulating, planar or irregular. Large scale roughness will be of less significance if the rock consists of small blocks.
See Table A3 of Figure 4.2 for further detail.

This parameter also depends on the thickness of the mineral filling in the crack. The roughness has less significance when the filling is thick and consists of low-friction material such as clay or chlorite. In the cases where contact between the two surfaces is not obtained before 10 cm of shear deformation, the J_r-value is set equal to 1 (Løset, 1997).

The direction of roughness compared to the most likely slip-direction must be considered and the J_r-parameter is to be estimated for the most unfavourable set according to tunnel stability.
$J_{r\ max} = 4$ for discontinuous joints, $J_{r\ min} = 0.5$ for slickensided, planar joints.

J_a: Filling and wall-rock alteration

J_a describes the minerals and filling the joints consist of. There are two main factors to be taken into consideration; type and thickness of the filling. Hard minerals may strengthen the rock mass, but phyllo-silicate (clay minerals) filling may lead to a decrease in joint friction and hence reduce the rock mass stability.
The value of this parameter may be divided into three main categories depending on the thickness of the filling; [1)]rock wall contact, [2)]rock wall contact before 10 cm shear and [3)]no rock-wall contact when sheared. See Table A4 of Figure 4.2 for further detail.

Subsequent to the determination of the thickness of the filling, the parameter is given a numerical value depending on the mineral content of the filling. The mineral content may in some cases require a closer determination by laboratory investigations.
$J_{a\ max} = 20$ for thick, continuous clay zones, $J_{a\ min} = 0.75$ for tightly healed joints.

4.2.3 Stress conditions (J_w/SRF)

This ratio considers the effect of different combinations of stresses within a rock mass and type of rock in question. The stresses acting within a rock mass will depend on several conditions including depth below surface, topography and tectonic environment of the subsurface, in addition to the water pressure along the joints. The stability of the rock mass depends on the size of the stresses compared to the strength of the rock and rock joint in question. This may vary within short distances along a profile, due to variations in lithology and mineral filling of joints (Løset 1997).

J_w: Water conditions

J_w describes the reduction of effective normal stresses as a consequence of water conditions in the joints within the rock mass in addition to possible changes in stability due to the solution or removal of mineral filling due to circulation of water. As the water pressure in the crack increases the effective joint friction decreases, hence decreasing the rock mass stability (Løset, 1997). In many cases the filling may be mechanically weakened or washed out in the presence of water.

Water leakages into an underground opening may vary through time so it is of importance to note the time of investigation compared to the time of excavation.

See Table A5 in Figure 4.2 for further details.

$J_{w\ max}$ = 1.0 for dry to damp conditions, $J_{w\ min}$ = 0.05 for exceptionally high inflow or water pressure.

The J_w-parameter may also be estimated through permeability investigations in bore holes during the stages of pre-investigation.

SRF: Stress reduction factor

In general this parameter describes the relation between rock stresses and rock strength in an excavation where the degree of fracturing, content of swelling clay minerals and the uni-axial compressional strength (σ_c) of the rock are taken into consideration. Both stress and strength are measurable quantities, and SRF can be calculated from the ratio between the uni-axial compressional strength (σ_c) and the largest principal stress (σ_1).

For a tunnel major principal stress is the maximal tangential stress (σ_θ).

The SRF-factor in Table A6 in Figure 4.2 is divided into four categories (Barton, 2002):

(a) Weakness zones intersecting excavations.

A reduction in stresses may result in the lack of interlocking and may result in the downfall of blocks from the roof and upper walls of the excavation.

(b) Competent rock, rock stress problems.

Low stresses result in the lack of interlocking, whereas high stresses result in slabbing/spalling and rock burst.

(c) Squeezing rock.

The squeezing of rock occurs when the uni-axial compressional strength of the rock is exceeded. The rock experiences plastic deformation.

(d) Swelling rock.

As swelling minerals come in contact with water they will induce a volume increase due to the uptake of water in the mineral structure.

Figure 4.2: Table A1-A6 from Barton (2002) giving the parameters of the Q-system and their values.

Table A1

Rock quality designation		RQD (%)
A	Very poor	0–25
B	Poor	25–50
C	Fair	50–75
D	Good	75–90
E	Excellent	90–100

Notes: (i) Where RQD is reported or measured as ⩽10 (including 0), a nominal value of 10 is used to evaluate Q. (ii) RQD intervals of 5, i.e., 100, 95, 90, etc., are sufficiently accurate.

Table A2

Joint set number		J_n
A	Massive, no or few joints	0.5–1
B	One joint set	2
C	One joint set plus random joints	3
D	Two joint sets	4
E	Two joint sets plus random joints	6
F	Three joint sets	9
G	Three joint sets plus random joints	12
H	Four or more joint sets, random, heavily jointed, 'sugar-cube', etc.	15
J	Crushed rock, earthlike	20

Notes: (i) For tunnel intersections, use ($3.0 \times J_n$). (ii) For portals use ($2.0 \times J_n$).

Table A3

Joint roughness number		J_r
(a) *Rock-wall contact, and (b) rock-wall contact before 10 cm sear*		
A	Discontinuous joints	4
B	Rough or irregular, undulating	3
C	Smooth, undulating	2
D	Slickensided, undulating	1.5
E	Rough or irregular, planar	1.5
F	Smooth, planar	1.0
G	Slickensided, planar	0.5
(b) *No rock-wall contact when sheared*		
H	Zone containing clay minerals thick enough to prevent rock-wall contact.	1.0
J	Sandy, gravely or crushed zone thick enough to prevent rock-wall contact	1.0

Notes: (i) Descriptions refer to small-scale features and intermediate scale features, in that order. (ii) Add 1.0 if the mean spacing of the relevant joint set is greater than 3 m. (iii) $J_r = 0.5$ can be used for planar, slickensided joints having lineations, provided the lineations are oriented for minimum strength. (iv) J_r and J_a classification is applied to the joint set or discontinuity that is least favourable for stability both from the point of view of orientation and shear resistance, τ(where $\tau \approx \sigma_n \tan^{-1}(J_r/J_a)$.

Table A4

Joint alteration number		ϕ_r approx. (deg)	J_a
(a) *Rock-wall contact (no mineral fillings, only coatings)*			
A	Tightly healed, hard, non-softening, impermeable filling, i.e., quartz or epidote	—	0.75
B	Unaltered joint walls, surface staining only	25–35	1.0
C	Slightly altered joint walls, non-softening mineral coatings, sandy particles, clay-free disintegrated rock, etc.	25–30	2.0
D	Silty- or sandy-clay coatings, small clay fraction (non-softening)	20–25	3.0
E	Softening or low friction clay mineral coatings, i.e., kaolinite or mica. Also chlorite, talc, gypsum, graphite, etc., and small quantities of swelling clays	8–16	4.0
(b) *Rock-wall contact before 10 cm shear (thin mineral fillings)*			
F	Sandy particles, clay-free disintegrated rock, etc.	25–30	4.0
G	Strongly over-consolidated non-softening clay mineral fillings (continuous, but <5 mm thickness)	16–24	6.0
H	Medium or low over-consolidation, softening, clay mineral fillings (continuous, but <5 mm thickness)	12–16	8.0
J	Swelling-clay fillings, i.e., montmorillonite (continuous, but <5 mm thickness). Value of J_a depends on per cent of swelling clay-size particles, and access to water, etc.	6–12	8–12
(c) *No rock-wall contact when sheared (thick mineral fillings)*			
KLM	Zones or bands of disintegrated or crushed rock and clay (see G, H, J for description of clay condition)	6–24	6, 8, or 8–12
N	Zones or bands of silty- or sandy-clay, small clay fraction (non-softening)	—	5.0
OPR	Thick, continuous zones or bands of clay (see G, H, J for description of clay condition)	6–24	10, 13, or 13–20

Table A5

	Joint water reduction factor	Approx. water pres. (kg/cm^2)	J_w
A	Dry excavations or minor inflow, i.e., < 5 l/min locally	< 1	1.0
B	Medium inflow or pressure, occasional outwash of joint fillings	1–2.5	0.66
C	Large inflow or high pressure in competent rock with unfilled joints	2.5–10	0.5
D	Large inflow or high pressure, considerable outwash of joint fillings	2.5–10	0.33
E	Exceptionally high inflow or water pressure at blasting, decaying with time	> 10	0.2–0.1
F	Exceptionally high inflow or water pressure continuing without noticeable decay	> 10	0.1–0.05

Notes: (i) Factors C to F are crude estimates. Increase J_w if drainage measures are installed. (ii) Special problems caused by ice formation are not considered. (iii) For general characterisation of rock masses distant from excavation influences, the use of J_w = 1.0, 0.66, 0.5, 0.33, etc. as depth increases from say 0–5, 5–25, 25–250 to > 250 m is recommended, assuming that RQD/J_n is low enough (e.g. 0.5–25) for good hydraulic connectivity. This will help to adjust Q for some of the effective stress and water softening effects, in combination with appropriate characterisation values of SRF. Correlations with depth-dependent static deformation modulus and seismic velocity will then follow the practice used when these were developed.

Table A6

Stress reduction factor		SRF		
(a) *Weakness zones intersecting excavation, which may cause loosening of rock mass when tunnel is excavated*				
A	Multiple occurrences of weakness zones containing clay or chemically disintegrated rock, very loose surrounding rock (any depth)	10		
B	Single weakness zones containing clay or chemically disintegrated rock (depth of excavation ⩽ 50 m)	5		
C	Single weakness zones containing clay or chemically disintegrated rock (depth of excavation > 50 m)	2.5		
D	Multiple shear zones in competent rock (clay-free), loose surrounding rock (any depth)	7.5		
E	Single shear zones in competent rock (clay-free), (depth of excavation ⩽ 50 m)	5.0		
F	Single shear zones in competent rock (clay-free), (depth of excavation > 50 m)	2.5		
G	Loose, open joints, heavily jointed or 'sugar cube', etc. (any depth)	5.0		
		σ_c/σ_1	σ_θ/σ_c	SRF
(b) *Competent rock, rock stress problems*				
H	Low stress, near surface, open joints	> 200	< 0.01	2.5
J	Medium stress, favourable stress condition	200–10	0.01–0.3	1
K	High stress, very tight structure. Usually favourable to stability, may be unfavourable for wall stability	10–5	0.3–0.4	0.5–2
L	Moderate slabbing after > 1 h in massive rock	5–3	0.5–0.65	5–50
M	Slabbing and rock burst after a few minutes in massive rock	3–2	0.65–1	50–200
N	Heavy rock burst (strain-burst) and immediate dynamic deformations in massive rock	< 2	> 1	200–400
		σ_θ/σ_c	SRF	
(c) *Squeezing rock: plastic flow of incompetent rock under the influence of high rock pressure*				
O	Mild squeezing rock pressure	1–5	5–10	
P	Heavy squeezing rock pressure	> 5	10–20	
		SRF		
(d) *Swelling rock: chemical swelling activity depending on presence of water*				
R	Mild swelling rock pressure	5–10		
S	Heavy swelling rock pressure	10–15		

Notes: (i) Reduce these values of SRF by 25–50% if the relevant shear zones only influence but do not intersect the excavation. This will also be relevant for characterisation. (ii) For strongly anisotropic virgin stress field (if measured): When $5 \leqslant \sigma_1/\sigma_3 \leqslant 10$, reduce σ_c to $0.75\sigma_c$. When $\sigma_1/\sigma_3 > 10$, reduce σ_c to $0.5\sigma_c$, where σ_c is the unconfined compression strength, σ_1 and σ_3 are the major and minor principal stresses, and σ_θ the maximum tangential stress (estimated from elastic theory). (iii) Few case records available where depth of crown below surface is less than span width, suggest an SRF increase from 2.5 to 5 for such cases (see H). (iv) Cases L, M, and N are usually most relevant for support design of deep tunnel excavations in hard massive rock masses, with RQD/J_n ratios from about 50–200. (v) For general characterisation of rock masses distant from excavation influences, the use of SRF = 5, 2.5, 1.0, and 0.5 is recommended as depth increases from say 0–5, 5–25, 25–250 to > 250 m. This will help to adjust Q for some of the effective stress effects, in combination with appropriate characterisation values of J_w. Correlations with depth-dependent static deformation modulus and seismic velocity will then follow the practice used when these were developed. (vi) Cases of squeezing rock may occur for depth $H > 350Q^{1/3}$ according to Singh [34]. Rock mass compression strength can be estimated from $\mathrm{SIGMA}_{cm} \approx 5\gamma Q_c^{1/3}$ (MPa) where γ is the rock density in t/m^3, and $Q_c = Q \times \sigma_c/100$, Barton [29].

4.3 Tunnel support measures: Application in general

The calculated Q-value and the six parameter values that comprise it can be used to determine the safety measures needed for that given value, as shown in Figure 4.3. A certain Q-value corresponds to a specific stability situation and requires a certain security measure.

When applying the security measure there are two additional factors that need to be taken into consideration;

(1) the span of the excavation (in meters m)

and

(2) the safety required for that specific excavation (ESR).

The relation between the two is given by

$$\frac{Span(m)}{ESR} = Equivalent\,diameter$$ (Løset, 1997).

To determine the support measures needed for a specific Q-value, the equivalent diameter is plotted on one axis and the Q-value on the other, and the type of support measure can be found. See Figure 4.3.

When securing the walls of an excavation the demand for security is generally lower than for the roof. The security measures needed for walls take the height of the wall into consideration in stead of the span of the opening. In addition to this, the Q-value is multiplied with a factor larger than 1 in the following way:

- For rock masses in the wall of good quality (Q > 10) the actual Q-value is multiplied by a factor of 5.
- For rock masses of moderate quality (0,1 < Q < 10) the actual Q-value is multiplied by a factor of 2,5. For cases where the SRF-value is high (spalling rock or rock bursts) the actual Q-value is retained.
- For rock masses of poor quality (Q < 0,1) the actual Q-value is retained.

When the re-calculation of the initial Q-value has been done, the diagram in Figure 4.3 can be used for estimation of the security measures needed for the walls of the excavation.

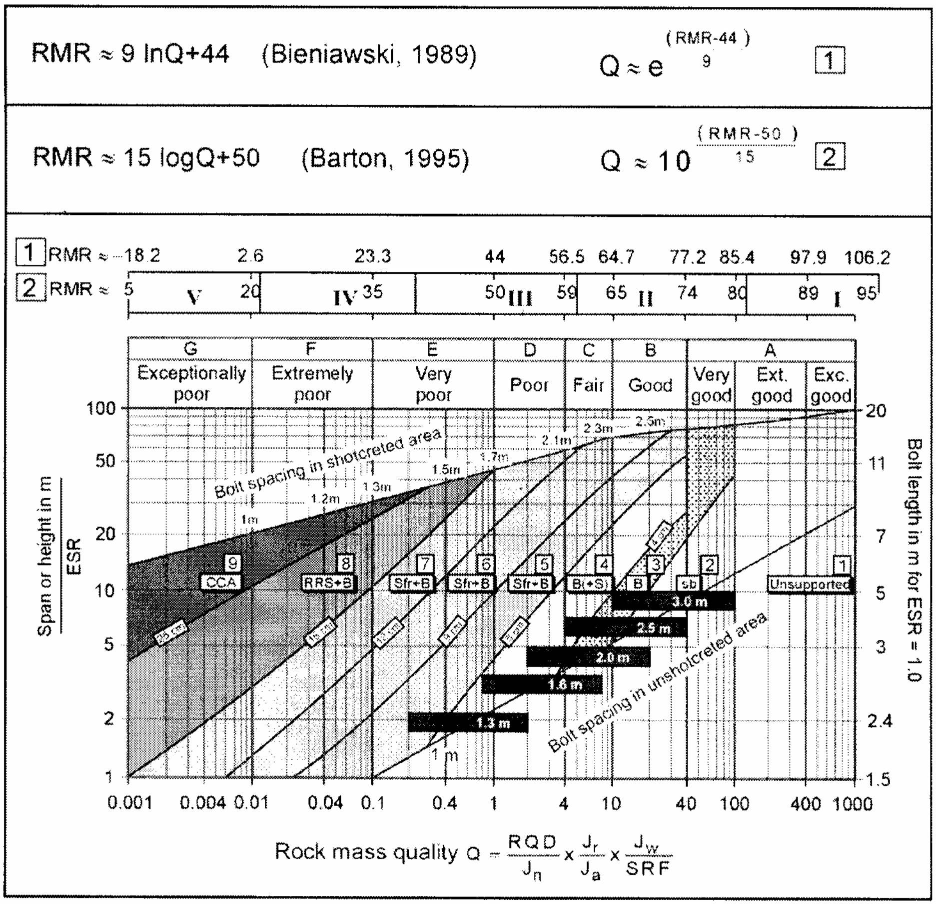


Fig 4.3: Q-system support (from Barton 2002). RMR refers to the “Rock mass rating” number first given by Bieniawski (1974).

The Q-system may also be used for supporting narrow zones of weakness. The support measures needed for narrow zones of weakness depend on the width of the zone, the orientation of the rock mass and the quality of the adjacent rock.

For a more detailed description of the Q-system and its application, the reader is advised to consult NGI Report 592046-2 “Ingeniørgeologi – Praktisk bruk av Q-metoden” by Fredrik Løset (1997).

4.4 Application of the Q-system to predict grout take

The Q-system was originally designed for rock mass classification and for required tunnel support evaluation. It has subsequently also been used to estimate TBM (Tunnel Boring Machine) progress rates (Barton, 2000).

There has been an increasing interest during the past few years to investigate other areas of application for this system. Any correlation that could be developed between the leakage into a tunnel or the amount of grout needed to tighten the tunnel and the Q-parameters would be extremely useful. Investigating this extended use of the Q-system was attempted by Bhasin (2002). He looked for correlations between the Q -system and its parameters and the grout take in the investigated tunnels.

In his report, Bhasin uses a modified Q-value, Q_i :

$$Q_i = \left(\frac{RQD}{J_n}\right) \times \left(\frac{J_r}{J_a}\right) \times \frac{1}{leakage\,(l/\min)\ /\,lengthofho\,le(m)}$$ (Bhasin, 2002).

Where

$\frac{RQD}{J_n}$ describes the degree of fracturing

$\frac{J_r}{J_a}$ describes frictional conditions along joints

$\frac{1}{leakage(l/\min)/lengthofhole(m)}$ is the inverse of the ratio between the leakage into the tunnel and the length of the probe borehole in which the leakage is measured. For a visual presentation of probe boreholes, see Figure 4.4 for details.

The last ratio $\left(\frac{J_w}{SRF}\right)$ in the original Q-system is replaced by a ratio describing the leakage into the tunnel and the length of boreholes where the leakage is measured.

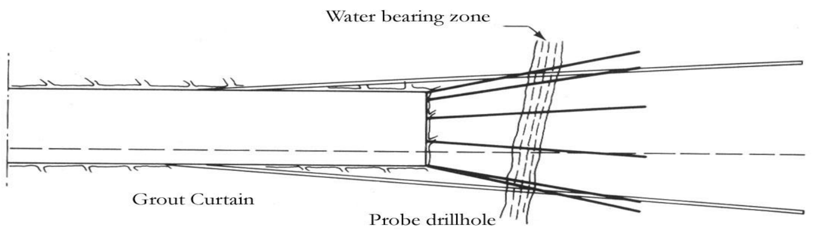


Figure 4.4 Probe drill hole installed from the tunnel face to detect potential zones of water inflow in the un-excavated sections of the tunnel.

He then establishes an empirical correlation between Q_i and the grout take, S_i, as follows:

$$Q_i = \frac{240}{S_i} \quad \text{or} \quad S_i = \frac{240}{Q_i} \qquad \text{(Bhasin, 2002).}$$

He proposes to use this simple equation to estimate the grout take for a specified leakage criterion within a section of the tunnel.

By mapping the tunnel, the first two ratios of the modified Q_i-value are known. The third ratio may be found by measuring the leakage in litres per minute from a borehole drilled into the tunnel face. In many cases the borehole is one of the many holes drilled in connection with the installation of the grout curtain, varying in length from 18 to 24 m.

Also, to extend the use of these equations, when given a certain water tightness criteria for a specific section along the trace of a tunnel (ex. 4l/min/100m tunnel) one may back-calculate S_i by first calculating the Q_i-value for the same section, assuming that the water inflow to the tunnel is through one specific borehole, 100 m in length.

The problem that arises when single boreholes are used is that the borehole may not penetrate the joints that conduct the largest amounts of water or penetrate joints that do not conduct water at all, and thereby may give misleading evaluations of S_i.

The work done in this thesis does not have as a goal to examine or prove the accuracy of the above relations for the JA1 Skaugum tunnel, but to investigate the correlations between the Q-values and corresponding parameters and geologic features in relation to the grout take to the tunnel.

Chapter 5

Systemization and treatment of data

5.1 Introduction

Prior to the construction of the JA1 tunnel, data was collected, treated, systemized and processed in such a way that it was accessible and understandable to the reader. This includes the making of reports within the different fields of expertise such as engineering geology and hydrogeology, and in the best way summarize and present the initial experiences made on site or in the laboratory. Several maps were presented by NGU (Norges Geologiske Undersøkelse) to aid and guide in the pre-investigations.
The numerous reports and data compilations made prior to construction are meant to guide and advise the designer and the contractor so they may be prepared for the varying rock conditions before construction, and so that unexpected difficulties can be avoided after construction has commenced, thereby reduce the uncertainties connected to the cost of construction.

As a part of the construction phase data is collected for every round of blasting in the tunnel and the data is registered and processed to optimize the understanding of the rock conditions as the work proceeds.
The engineering geologist on site is expected to map the new sections of the tunnel as they appear, using the Q-system as a main guide for determining the permanent support of the tunnel, as well as keeping an eye on the work the contractor is performing to ensure that everything is done according to procedure and contract.

During his/her work in the JA1 tunnel, the engineering geologist must analyze the stability of the new section of tunnel by identifying joint sets in the rock in addition to other structural features, type of lithology and establishing the parameters of the Q-system.

The engineering geologist is also required to:

- control the type and thickness of the layer of shotcrete and number of rock bolts used by the contractor when securing the tunnel for safe working conditions;
- obtain information of the amounts of grout injected and the time used during injection;
- generally update him/he self on how construction work is proceeding.

This data is then put into a system so it is accessible to the other colleagues at any given time.

5.2 Thesis data

To be able to treat the data analytically and thereby give a fairly scientific interpretation of the results, I found it advantageous to use an approach proposed by Churchman (1948).

This approach consists of ten steps:

1. Formulate the problem and note all possible answers.
2. Plan calculations to be able to solve the problem and to reject as many answers as possible.
3. Write down all steps conducted to collect the data.
4. Classify and summarize the raw data.
5. Re-work and analyze the raw data.
6. Draw conclusions from the analysis.
7. Erect a hypothesis based on the conclusions.
8. Predict new conclusions based on the hypothesis.
9. Test the new conclusions.
10. Accept or reject the new conclusions based on the test in point 9.

The procedure is not described step by step in the subsequent chapters, but the overall systematic analysis, conclusions and discussions exhibit the ideas presented by Churchman (1948).

5.2.1 Data base used

The data base used in this thesis was provided by the Norwegian Railroad Development department (JBV Utbygging), NGI and Mika, and consists of:

- Tunnel mapping by engineering geologists on site (JBV Utbygging).
- Autocad compilations of the tunnel mapping (JBV Utbygging).
- Grout injection tables for each grout curtain (Mika).
- Norconsult reports and maps concerning the section Jong – Asker (NGI).

The tunnel is still under construction and its completion is outside the time frame for this thesis. All work performed to process the data and analyze the results is based on data between chainage numbers 19.867 km and 22.780 km in addition to chainage numbers 23.540 km to 23.640 km. This is a total of 3013m of the total 3600m, or 84% of the total section.

Due to the nature of the structural geology in the area, most of the lithologic variations and structural features are well represented within these data.

5.2.2 The nature of the data

The nature of the data varies with the type of data collected as follows:

- *Grout tables, grout pressure and leakage data provided by Mika*

  The grout take data is presented in liters (l) and there is no differentiating between the types of grout recipes used or if the injected grout curtain is of a primary or secondary nature. The leakage data is in liters although the water tightness criterion is expressed as liters pr. minute pr. 100m tunnel.
- *Terrain to tunnel depth from Norconsult map USA75-6-T-JA1*

  All depths are measured in meters (m).
- *Q-values and values of the individual parameters, lithology, and structural geologic data provided by JBV Utbygging*

  Continuous mapping of the tunnel as it is excavated gives a good coverage. These data are non-dimensional, and the lithologic and structural descriptions are in addition non-numerical. Therefore, the numbers 1 to 4 are assigned to the four main rock types. It was also necessary to make the strike/dip data numerical by re-working the tunnel mapping sheets with a compass and an estimated direction of North. See Sub-section 5.2.3, “The orientation, dip and extent of structural features” for a closer description of the procedure used.

5.2.3 Quality of data

Grout and leakage data arise from the rig that performs the drilling or injection. For every grout curtain a print-out is made from the on-board computer, re-processed onto original Mika paper and handed over to JBV at the end of the week.
The quality of these data are expected to be good.

The Q-value and corresponding parameters are empirical numbers based on observations in the tunnel for the least favorable joint set orientation. As the roof of the tunnel is rarely accessible, the parameters have to be established by comparison of the joints in the walls or at the working face. Unfortunately, the J_w and SRF values were in most cases simply set equal to 1, reducing the number of effective parameters from 6 to 4 for calculating the Q-value.
The engineer is stressed for time during the mapping as this is done in the short time interval between the mechanical clearing of the fresh tunnel face and application of shot-crete for securing the tunnel for working purposes. The quality of these data are expected to be fair.

The orientation and extent of the structural features such as joints, faults and small-scale folds were drawn by free-hand onto the tunnel mapping sheet by the engineer without accurately measuring the features with a compass. The tunnel mapping sheets did not originally give the orientation of the tunnel compared to North but did to some extent give the dip of the mapped features. The strike values of layering and joint sets in the spread sheet are therefore obtained by the following method:

1. North is estimated by extrapolating the N-direction from JBVs Autocad compilation to the tangent of the tunnel at the specific chainage number.
2. The estimated angle of the tunnel at the specific chainage number compared to N (ex. 13°), is introduced to the tunnel mapping sheets.

3. The strike of the features on the tunnel mapping sheets compared to the estimated direction of N is established by compass and the “Right Hand Rule”.

Strike and dip values are measured using a 360° compass and registered by the “Right Hand Rule”. This means that one establishes the strike direction by its dip:

- if the rock dips to the right, the compass is read looking away from the mapper
- if the rock dips to the left the compass is read looking toward the mapper.

The quality of these data is expected to be fair.

Geologic features along the trace of the tunnel, occurring mainly as faults, are to a large extent not mapped as faults. They are denoted as clay-filled joints or zones of weakness, sometimes accompanied by a comment concerning the quality of the adjacent rock. The RQD and J_n values do not reflect these comments systematically.
It has therefore been necessary to interpret these structures by the descriptive tunnel mapping and by the aid of maps and literature concerning the faulting pattern of the regional, large scale area. The quality of these data is expected to be fair.

Lithology varies along the trace of the tunnel, and there seems to have been some difficulties establishing which rock type exists at the specific site. There does not seem to be a clear divide between clay and limestone shales as the engineering geologist did not carry a bottle of HCl, hydrochloric acid (1 Molar), with him/her for testing the rock. It has therefore been necessary to make a simplification in the spread sheet based on the on-site mapping:

- Nodular limestone = nodular limestone (1)
- Claystone = clay or siltstone shales (2)
- Limestone = limestone, calcareous shales (3)
- Sandstone = interbedded sandstone units (4)

In addition to the confusion about the bedrock, there seems to be uncertainties concerning the intrusive dikes that appear. The geology of the Oslo Region suggests four main types of intrusives: Diabase, micro Syenite, Syenite Porphyry and Rhomb Porphyry. These have not been differentiated during mapping and all dikes are mapped as “intrusives”.

Dikes of diabase usually appear strike parallel, while the micro syenittic dikes appear perpendicular to the strike of the bedrock (Nilsen, 2004). Intrusive dikes have been renamed in the spread sheet using the most abundant types of dikes; the Diabase and micro Syenite.

The quality of these data is poor to fair and may only be regarded as lithologic guidelines.

5.3 Systemizing and re-working of data

5.3.1 Design of the MS Excel spread sheet

The above data have been put together in an Microsoft Excel spread sheet to give a better survey and make the handling of them easier. An example of the spread sheet is given in Table 5.1 below. See Appendix A for the total compilation spread sheets.

Table 5.1 Example of the MS Excel spread sheet.

Data compillation toward Solstad.														
Chainage no.	Grout take (L)	Leakage (L)	Q´-value	RQD	Jn	Jr	Ja	Jw	SRF	RQD Jn	Jr Ja	Geology	Comment	Layering strike/dip

The design of the spread sheet is kept as simple as possible, listing the variables such as chainage number, grout take, the parameters of the Q-system and lithologic variation among others along the x-axis, and their corresponding values at specific chainage numbers along the z-axis. Where sums or differences between values occur, the mathematic formula that gives the relationship is introduced so there should be no confusion as to how the value was derived. See enclosed cd with thesis data for verification.

As the construction of the tunnel proceeds from three working faces, the order of chainage numbers from one working face may be ascending, while from another it may be descending. The spread sheet shows no differentiation between the direction of how the tunnel was excavated, but lists all values in an ascending order. This makes the semi-statistical analysis more lucid in terms of graphic visualization.

5.3.2 Semi-statistical analysis

The goal of this thesis requires the investigation of any statistical or non-statistical relation between grout take and the parameters of the Q-system.

To be able to study this, it was necessary to make a spread sheet compilation to classify and summarize the raw data. By doing this the data becomes accessible for making graphic, statistical presentations of any relations that may or may not exist between the parameters in question.

By plotting one parameter vs. another and adding a trend line to the graphical plot, I have been able to give a correlation factor for each plot through a determination coefficient r^2. The determination coefficient r^2 is a statistical parameter which gives the degree of correlation between the variances of the data points of the plotted parameters, as a value $1 \leq r^2 \leq -1$.

$r^2 = 1$ for perfect correlation

$r^2 = 0$ for no correlation

$r^2 = -1$ for perfect negative correlation

For all practical purposes there is no correlation between two parameters when $r^2 < 0.5$.

5.3.3 Sub-division of tunnel trace for Q-value purposes

In order to optimize correlation results, the tunnel has been divided into segments of fairly similar Q-values and analyzed in chainage number sections along its trace. See Table 5.2 on next page for illustration.

By doing this it is easier to obtain maximum and minimum values in addition to a mean value within that certain section of the tunnel.

The parameters plotted, one against the other, are:

- Grout take, Q-value, RQD, J_n, J_r, J_a, J_w, and SRF vs. chainage number.
- Q-value, RQD, J_n, J_r, J_a, J_w, and SRF vs. grout take.
- RQD/J_n, J_r/J_a, and J_w/SRF and lithology vs. grout take.

Table 5.2. Example of segments of fairly similar Q-values.

Data compillation Total Section.													
Chainage no.	**Grout take (L)**	**Leakage (L)**	**Q´-value**	**RQD**	**Jn**	**Jr**	**Ja**	**Jw**	**SRF**	**RQD/Jn**	**Jr/Ja**	**Geology**	
20017	16008	71	12,5	75	6	2	2	1	1	13	1	Limestone	
20021,5			10,8	65	6	2	2	1	1	11	1	Limestone	
20027			10,0	60	6	2	2	1	1	10	1	Claystone	
20032	9474,2	8,5	11,7	70	6	2	2	1	1	12	1	Claystone	
20039			15,0	60	4	2	2	1	1	15	1	Claystone	
20043,5			15,0	60	4	2	2	1	1	15	1	Claystone	
20048	8661,3	121,5	10,8	65	6	2	2	1	1	11	1	Claystone	

See Appendix B for further details and the total spread sheet.

5.4 The new geologic profile

For tunnel construction the Norconsult map and profile USA72-6-T-V02002 among others, are being used daily by JBV Utbygging in their interpretation of the geologic features along the trace of the tunnel. As the construction of the tunnel proceeds and the engineering geologists on site map the new sections as they appear, a vast amount of new data concerning the true geology of the tunnel is revealed. It was therefore necessary to systemize the data from the new sections into a geologic profile so that the data became more accessible. The compilation of data has also made it possible to re-design the geologic profile along the trace of the tunnel from the Norconsult map.

5.4.1 Sub-division of tunnel trace for structural geologic purposes

To aid in this the data collected along the tunnel trace has once again been sub-divided into sections. The original sections mentioned in chapter 5.3.3 used for the interpretation of Q-values and Q parameters are not valid for this as it is the specific structural geologic features along the trace that are of interest. This sub-dividing of the tunnel into chainage number regions arises from suggestions that faults have a tendency to consist of fault gouge (zone A, Section 2.5.2) which seals the joints and makes them impermeable for both water and grout, in contrast to the B and C zones which often exhibit increased permeability after faulting. Folds may be more susceptible to injected grout alo ng their hinges because of a close joint pattern, and dikes may suffer heavier fracturing due to competence contrast to the surrounding rock. Therefore, I found it necessary to erect new sections based on folded and faulted rock, rock cut by dikes and "undisturbed" rock. See Table 5.3 below for an example.

Table 5.3. Example of sub-division of the tunnel trace for structural geologic purposes.

Sub-division structural features														
Chainage no.	Grout take (L)	Grout pr.m tunnel	Q´-value	RQD	Jn	Jr	Ja	Jw	SRF	RQD/Jn	Jr/Ja	Geology		Comment
20791	13541	90	6,1	55	6	2	3	1	1	9,2	0,7	Claystone	2	fault layer ll 3m
20795,5			6,1	55	6	2	3	1	1	9,2	0,7	Claystone	2	
20801			4,4	40	6	2	3	1	1	6,7	0,7	Claystone	2	
20806	1589,2		4,1	37	6	2	3	1	1	6,2	0,7	Claystone	2	Fault 093/45

See Appendix D for further details on the sub-division of the total trace of the tunnel.

5.4.2 Additional borehole data

Along the trace and in the vicinity of the tunnel, several boreholes have been drilled. These have water pressure sensors installed in them today to aid in the ground water surveillance program (See Chapter 1.4.5). Cores have been extracted from these boreholes and give excellent information about the lithology at different depths. For the JA1 tunnel, the boreholes K5, K6 and K7 were installed for this purpose. Unfortunately boreholes K5, K6 and K7 along the trace of the tunnel have been of limited value as it is only the K6 borehole that coincides with the section of tunnel described in this thesis. Still, it has readily been used to establish the lithology where it crosses the trace of the tunnel.

5.4.3 Seismic profiles

In addition to boreholes, seismic profiles USA72-6-T-V02041, -42, -43 and -44 from Norconsult exist along some sections of the tunnel. Seismic velocities of 4500-7500 m/s are common for non-fractured, consolidated rock, while velocities below 3500 m/s may

be obtained for fractured, water-filled rock and general zones of weakness. These profiles show low velocity zones at different sites, corresponding to zones of heavier jointed rock, inferring zones of potential high leakage and difficult rock conditions.
No fault rocks have been mentioned in the tunnel mapping to aid the interpretation although several large fault zones have been identified.

5.4.4 Rose diagrams

The rose diagram is a tool used to clearly illustrate mean orientations of joints in a specific area by visualizing them in a 360° diagram. By doing this the mean directions of the joints and their abundance compared to other joint orientations may be read directly from the diagram.
The strike and dip data from the spread sheet compilation have been divided into chainage number sections to better establish any relation between the orientation of the joint sets and grout take for the specific area. By the aid of the programs Note Pad and StereoWin 1.2 the additional jointing has been transformed into rose diagrams to better visualize the changes in joint pattern close to geologic features. The rose diagrams therefore do not contain the strike and dip of the layering of the rock mass.

In addition, a reproduced diagram of the total section has been made to compare to the original diagram by Norconsult. Figure 6.12 displays the rose diagram for the total section of the JA1 tunnel. See Appendix E for rose diagrams for the other structural geologic sections of the tunnel.

Chapter 6

Results of correlations

6. 1 Introduction

The systemization and re-working of data in Chapter 5 results in numerous graphical presentations of the Q-values, Q-system parameters and lithologic variations along the trace of the JA1 tunnel.

Adding a trend line for each plot, the determination coefficient r^2 gives the degree of correlation between the variances of the plotted parameters, indicating to what degree the parameters are connected.

In addition to the numerical presentation, a new geologic profile has been erected to give a detailed view of the mapped geology along the tunnel trace, and thereby to make it easier to relate grout take to geologic features.

Additional rose diagrams have been plotted to show joint orientations within specified chainage number sections aid in this interpretation.

6.2 Correlations of grout take with Q-values and Q-system parameters

As mentioned in Chapter 5, the parameters plotted, one against the other, are:

Grout take, Q-value, RQD, J_n, J_r, J_a, J_w, and SRF vs. chainage number

Q-value, RQD, J_n, J_r, J_a, J_w, and SRF vs. grout take

RQD/J_n, J_r/J_a, and J_w/SRF and lithology vs. grout take

Initially, all these variables were plotted for individual sections of similar Q-values along the tunnel. However, if the plot only consists of two data points, i.e two grout curtain injection values and corresponding Q-values/parameters, there will be a perfect linear relationship between them corresponding to a r^2-value of 1. According to Section 5.3.2 this means that there exists a perfect correlation between the variables of the two parameters. This relation may be very misleading. When more than three data points are plotted, the r^2-value decreases rapidly. On the basis of this, the data have therefore also been plotted "all in one" and not only for individual sections with similar Q-value, and the trend line added subsequently. The following interpretation is on the base of the latter re-working of datC.

6.2.1 MS Excel graphic presentation

All correlations are plotted, although as discussed in Chapter 7, the determination of several of the Q-system parameters contain very large uncertainties and deficiencies.

Q-value vs. grout take:

Figure C.1 (Appendix C) shows the variation in Q-value with chainage number along the tunnel. Figure C.2 (Appendix C) shows the variation in grout take with chainage number along the tunnel.

Combining these two parameters, Figure 6.1 shows how the Q-value varies with grout take for the total section of the tunnel.

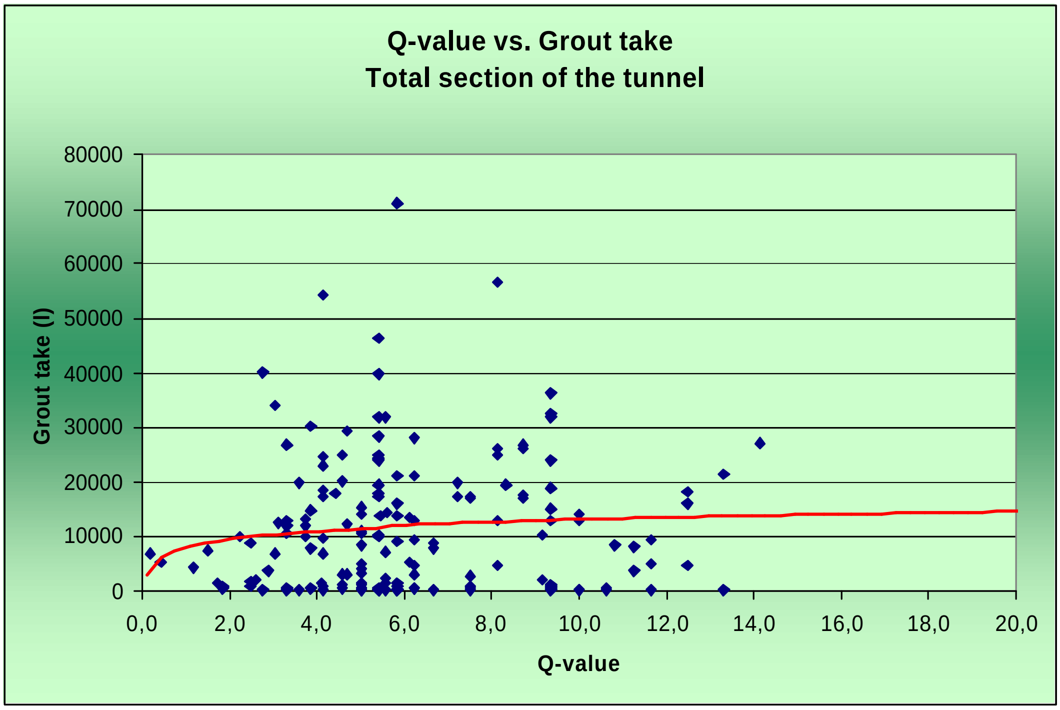


Figure 6.1: Relationship between Q-value and grout take for the total section of the tunnel. Trend line is indicated in red.

RQD vs. grout take:

Figure C.4 (Appendix C) shows the variation in RQD-value (rock quality designation) with chainage number along the tunnel. Figure C.2 (Appendix C) shows the variation in grout take with chainage number along the tunnel.

Combining these two parameters, Figure 6.2 shows how the RQD-value varies with grout take for the total section of the tunnel.

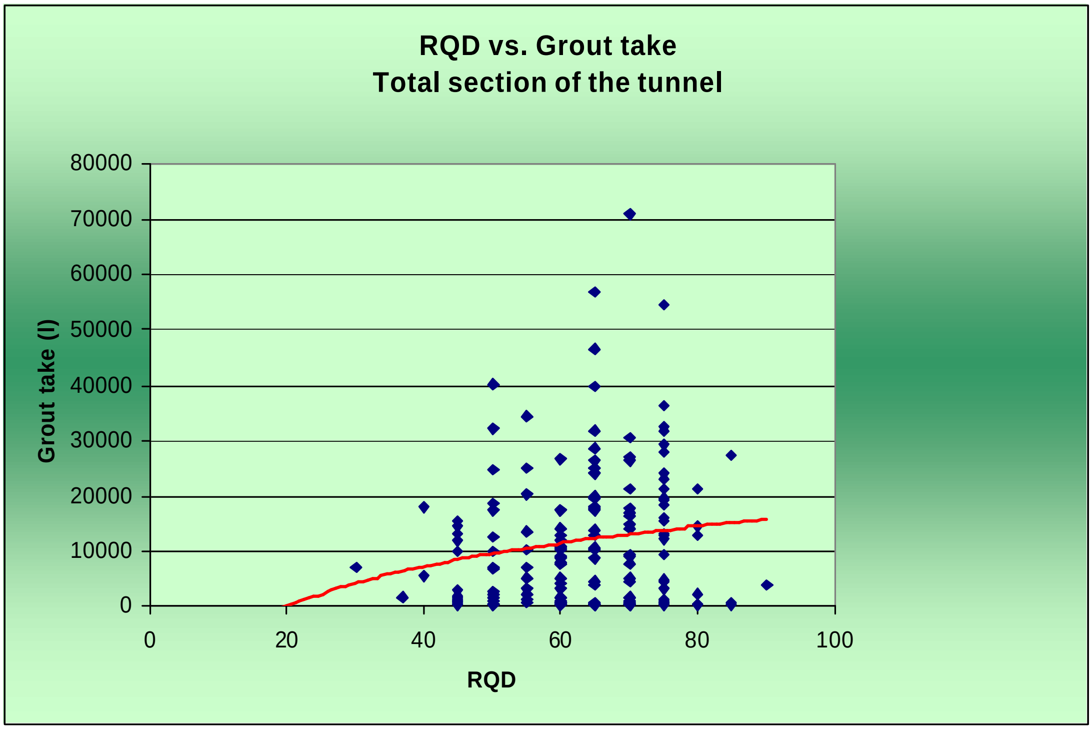


Figure 6.2: Relationship between RQD-value and grout take for the total section of the tunnel. Trend line is indicated in red.

J_n vs. grout take:

Figure C.6 (Appendix C) shows the variation in Jn-value (joint set number) with chainage number along the tunnel. Figure C.2 (Appendix C) shows the variation in grout take with chainage number along the tunnel.

Combining these two parameters, Figure 6.3 shows how the Jn-value varies with grout take for the total section of the tunnel.

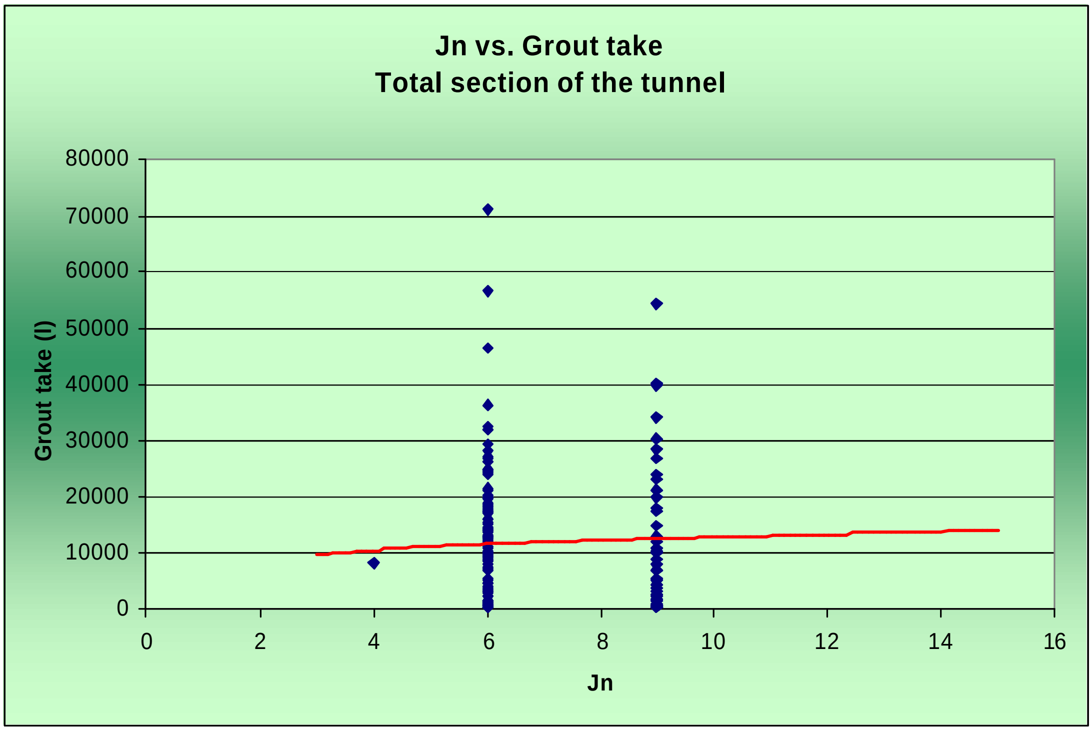


Figure 6.3: Relationship between J_n-value and grout take for the total section of the tunnel. Trend line is indicated in red.

RQD/J_n vs. grout take:

Figure C.16 (Appendix C) shows the variation in RQD/ J_n-value (degree of fracturing) with chainage number along the tunnel. Figure C.2 (Appendix C) shows the variation in grout take with chainage number along the tunnel. Combining these two parameters, Figure 6.4 shows how the RQD/ J_n-value varies with grout take for the total section of the tunnel.

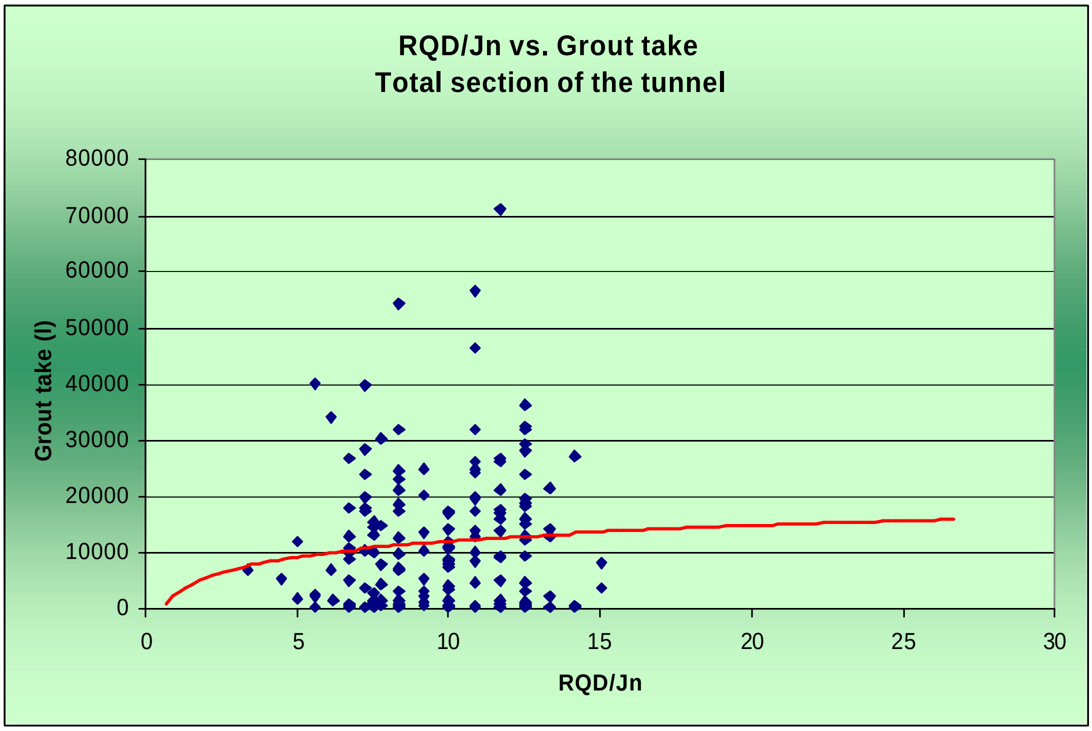


Figure 6.4: Relationship between RQD/J_n-value (degree of fracturing) and grout take for the total section of the tunnel. Trend line is indicated in red.

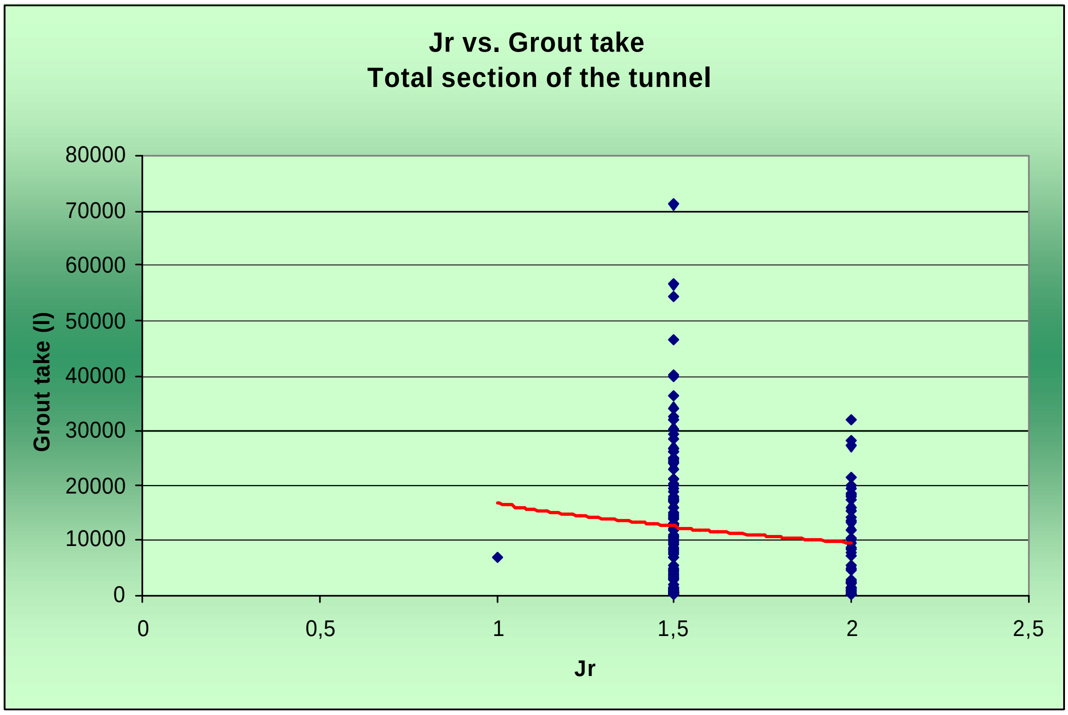


Figure 6.5: Relationship between J_r-value and grout take for the total section of the tunnel. Trend line is indicated in red.

Jr vs. grout take:

Figure C.8 (Appendix C) shows the variation in J_r-value (joint roughness number) with chainage number along the tunnel. Figure C.2 (Appendix C) shows the variation in grout take with chainage number along the tunnel.

Combining these two parameters, Figure 6.5 (previous page) shows how the J_r-value varies with grout take for the total section of the tunnel.

Ja vs. grout take:

Figure C.10 (Appendix C) shows the variation in J_a-value (joint alteration number) with chainage number along the tunnel. Figure C.2 (Appendix C) shows the variation in grout take with chainage number along the tunnel.

Combining these two parameters, Figure 6.6 shows how the J_a-value varies with grout take for the total section of the tunnel.

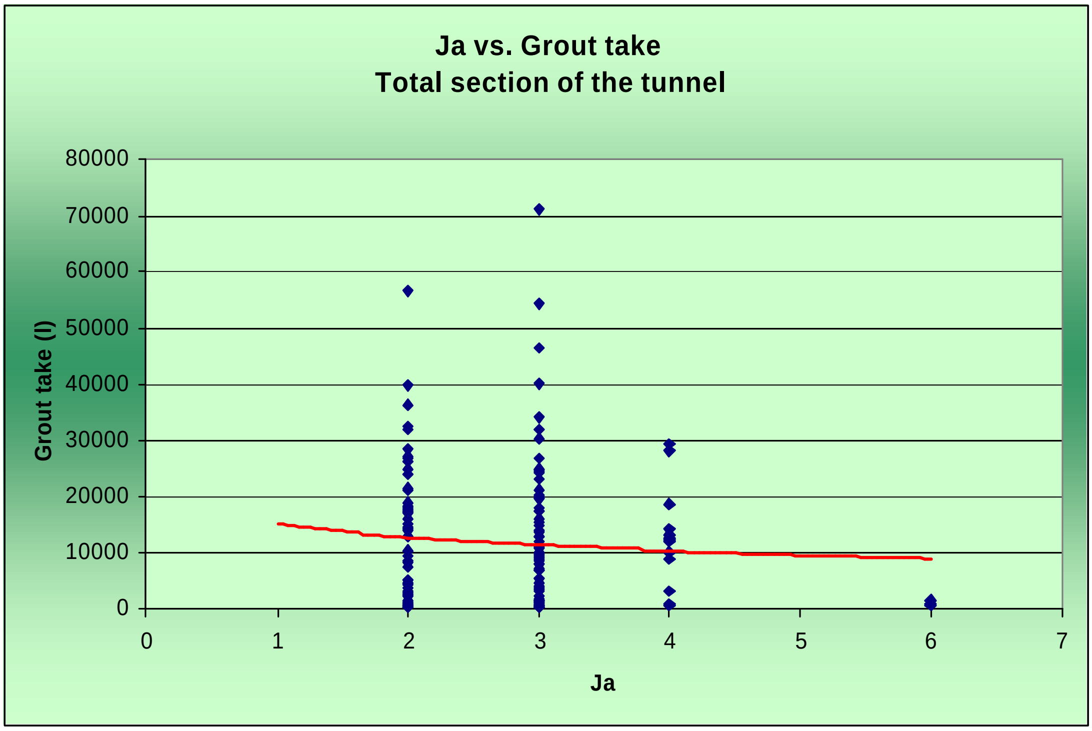


Figure 6.6: Relationship between J_a -value and grout take for the total section of the tunnel. Trend line is indicated in red.

Jr/Ja vs. grout take:

Figure C.18 (Appendix C) shows the variation in J_r/J_a-value (frictional conditions along joints) with chainage number along the tunnel. Figure C.2 (Appendix C) shows the variation in grout take with chainage number along the tunnel.

Combining these two parameters, Figure 6.7 shows how the J_r/J_a-value varies with grout take for the total section of the tunnel.

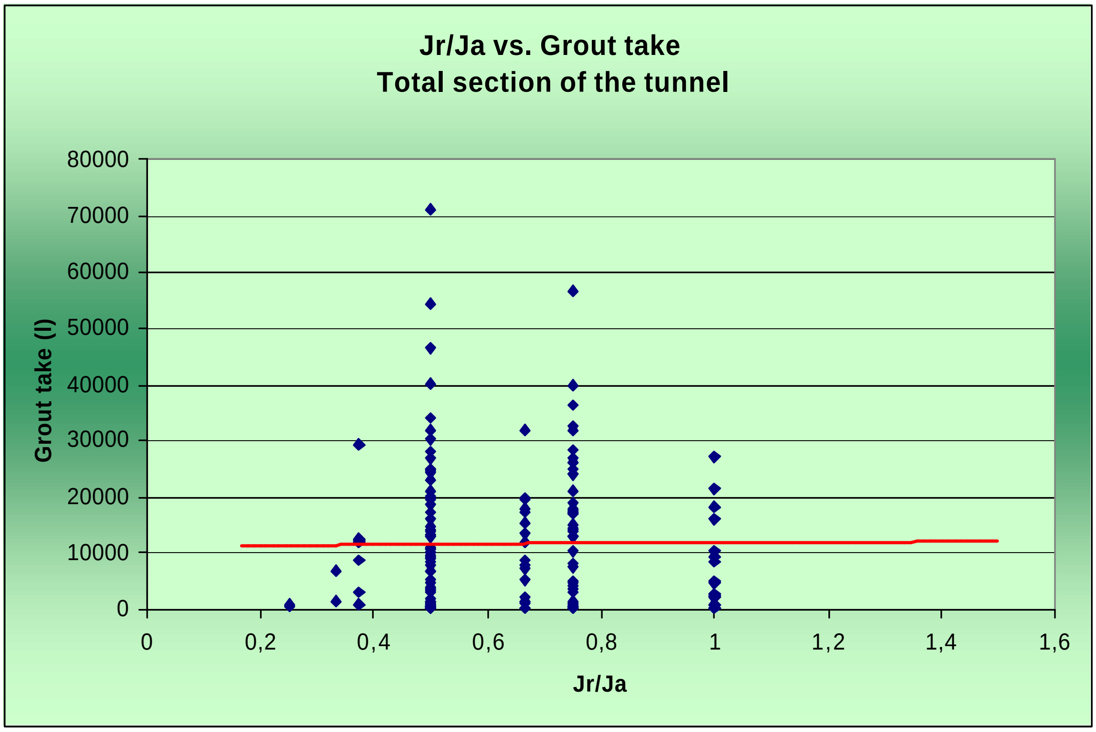


Figure 6.7: Relationship between J_r/J_a-value and grout take for the total section of the tunnel. Trend line is indicated in red.

J_w vs. grout take:

Figure C.12 (Appendix C) shows the variation in J_w-value (water conditions) with chainage number along the tunnel. Note that this value is for water conditions in the tunnel *after* the grout curtain is installed. Figure C.2 (Appendix C) shows the variation in grout take with chainage number along the tunnel.

Combining these two parameters, Figure 6.8 shows how the J_w-value varies with grout take for the total section of the tunnel.

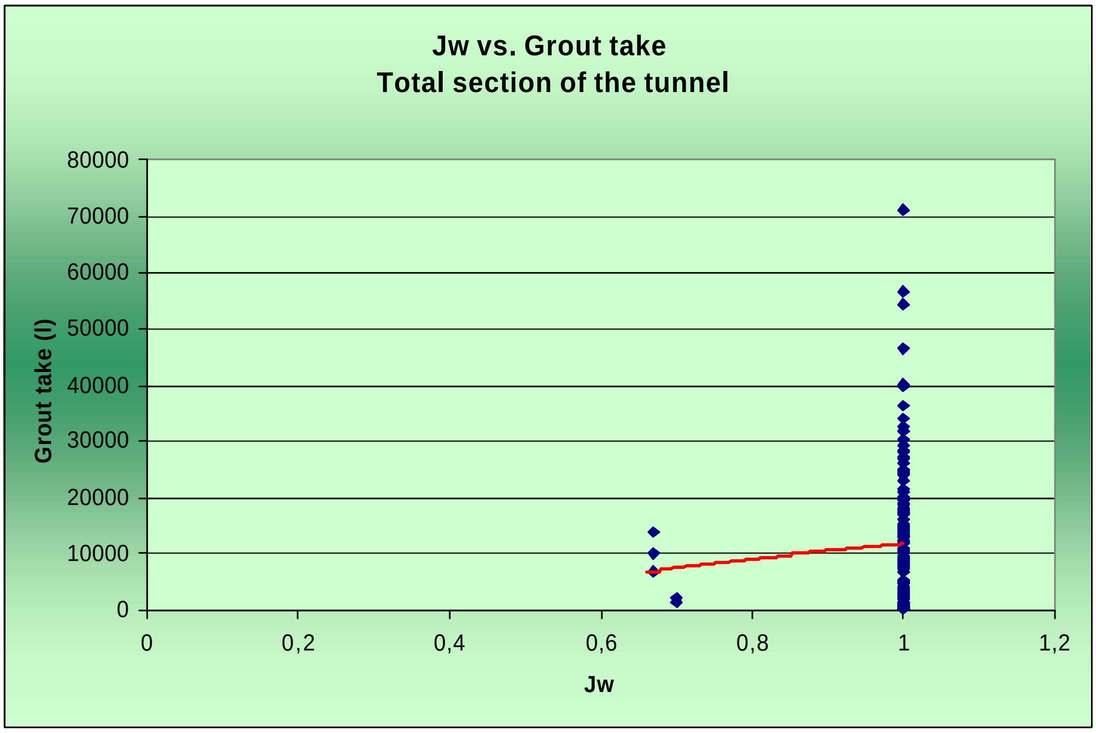


Figure 6.8: Relationship between J_w-value and grout take for the total section of the tunnel. Trend line is indicated in red.

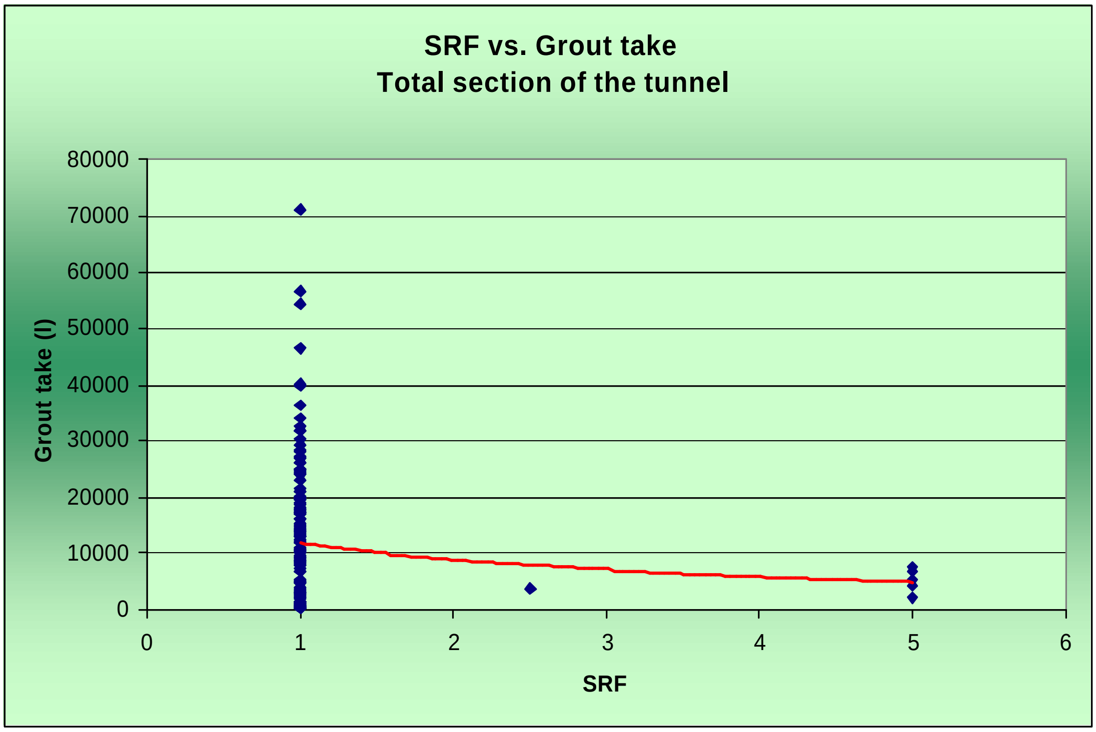


Figure 6.9: Relationship between SRF-value and grout take for the total section of the tunnel. Trend line is indicated in red.

SRF vs. grout take:

Figure C.14 (Appendix C) shows the variation in SRF-value (stress reduction factor) with chainage number along the tunnel. Figure C.2 (Appendix C) shows the variation in grout take with chainage number along the tunnel.

Combining these two parameters, Figure 6.9 (previous page) shows how SRF-value varies with grout take for the total section of the tunnel

J_w/SRF vs. grout take:

Figure C.20 (Appendix C) shows the variation in J_w/SRF-value (stress conditions) with chainage number along the tunnel. Figure C.2 (Appendix C) shows the variation in grout take with chainage number along the tunnel.

Combining these two parameters, Figure 6.10 shows how the J_w/SRF-value varies with grout take for the total section of the tunnel.

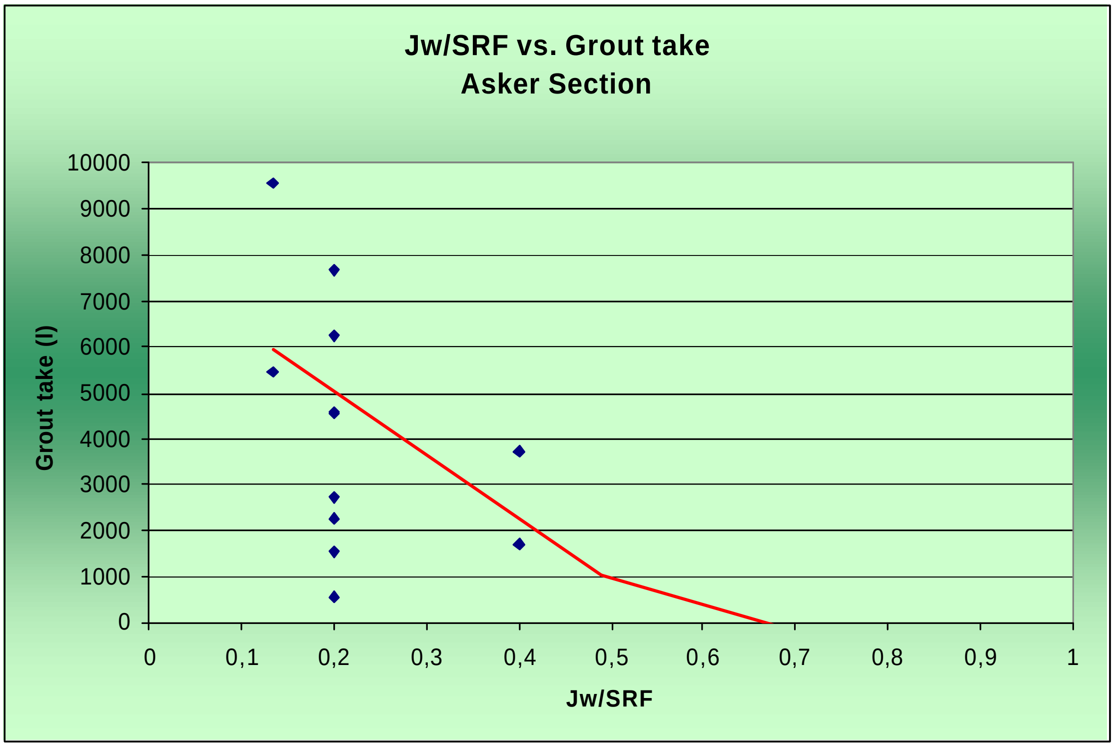


Figure 6.10: Relationship between J_w/SRF-value (stress conditions) and grout take for the total section of the tunnel. Trend line is indicated in red.

6.3 Correlation of grout take with structural features

6.3.1 Lithology vs. grout take:

Figure C.22 (Appendix C) shows the variation in lithology with chainage number along the tunnel. Figure C.2 (Appendix C) shows the variation in grout take with chainage number along the tunnel.

Combining these two parameters, Figure 6.11 shows how the lithology varies with grout take for the total section of the tunnel.

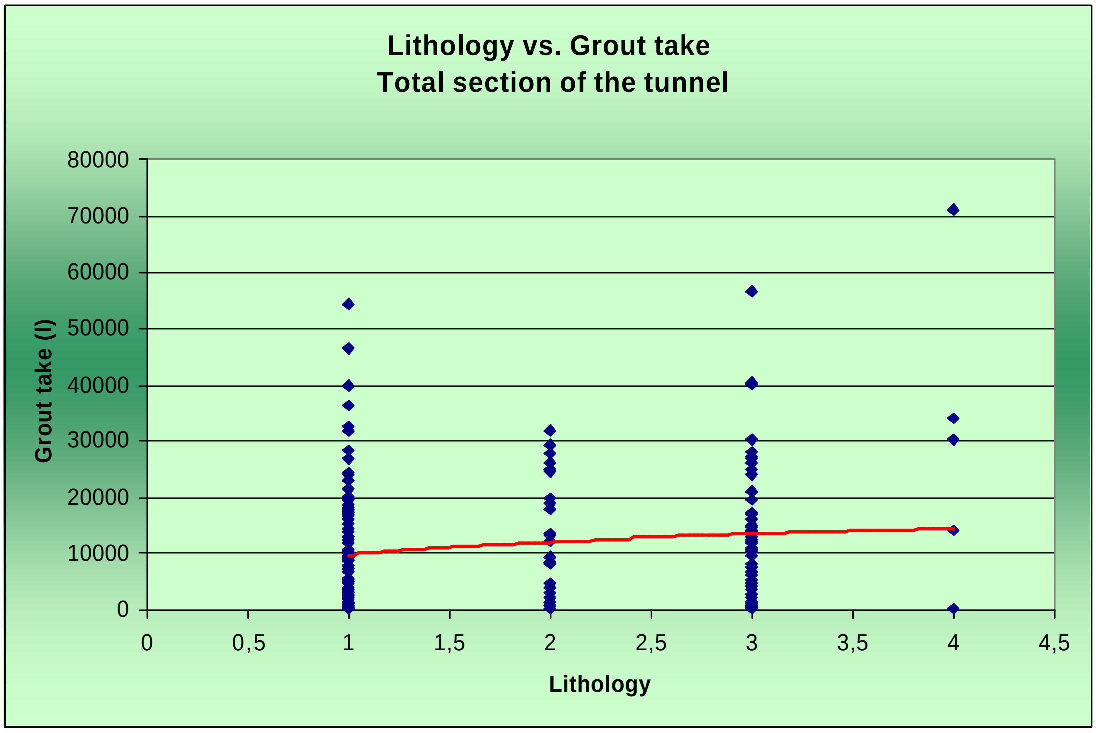


Figure 6.11: Relationship between lithology and grout take for the total section of the tunnel. Trend line is indicated in red. The lithologic variations are (1) Nodular limestone = nodular limestone, (2) Claystone = clay or siltstone shales, (3) Limestone = limestone, calcareous shales and (4) Sandstone = interbedded sandstone units.

6.3.2 Structural features

By systematically analyzing the tunnel mapping with regards to possible faults, folds and lithology and estimating the strike and dip of the features mapped, the "new geologic profile" based on the work of the engineering geologists has been re-produced by using MS Illustrator.

The new geologic profile is represented in Figure 6.13 at the end of this chapter.
As the new profile reflects the true geology of the tunnel to a larger extent than the Norconsult map USA72-6-T-V02002, it may explain more clearly why some sections of the tunnel are more prone to leakage or high grout take values than others. The lithologies reflected in Figure 6.13 are consistent with those described in Section 5.2.3 and with the Norconsult map mentioned above. As a consequence of the uncertainties described in Section 7.1.3, the lithology is only presented for a thin “strip” on either side if the trace of the tunnel. This should also apply for the structural features as described in Section 7.1.2, but in order to give the new profile a clearer appearance they are drawn throughout the new profile.

In addition to the profile in Figure 6.13, reworking of data in the MS Excel spread sheet has given specific values concerning the grout take for the different geologic structures. Although these values seem accurate, the reader must understand the uncertainties involved, and only use the values as guide lines.

Table 6.1 (next page) gives an overview of the results from the MS Excel spread sheet data treatment. Mean and special values are total values, and are given as grout take in liters pr. meter tunnel.

Dikes	
Mean values	Special case
2486	5020 (Dike + fault) 7702 (Dike + fault)
Folded	
Mean values	Special case
1728	6079 (Sandstone) 2003 (Fold + fault)
Faulted	
Mean values	Special case
1060	7759 (Thrust fault)
Non faulted	
Mean values	Special case
859	1180 (In between faults) 1855 (Close to dike) 1893 (Close to dike) 2268 (Sandstone) 2406 (Close to thrust fault)

Table 6.1

Result of systemizing data with emphasis on structural geologic features in the JA1 tunnel. Results are listed by descending values. Mean and special case values represent grout take (l) pr. m tunnel.

6.3.3 Joint orientation

The rose diagram is a tool used to more clearly illustrate mean orientations of joints in a specific area by visualizing them in a 360° diagram. By doing this the mean directions of the joints and their abundance compared to other joint orientations may be read directly from the diagram.

The trace of the tunnel divided into chainage number sections is for this case the same as for the structural analysis (Section 5.3.4) and for construction of rose diagrams (Section 5.3.5). See Figure 6.12 for rose diagram of the total section of the tunnel.

For ***structurally "quiet" rock masses*** the mean value of grout take, as illustrated in Table 6.1, is approximately 900 l pr. m tunnel. These sections of the tunnel exhibit additional jointing similar to that in the other sections of the tunnel.

The increased values of grout take pr. m tunnel occur when the mapped joint sets 2, 3, and 4 of the tunnel are oriented perpendicular to the rock mass layering and/or with an angle of 30° to 45° to the strike of the layering of the rock (joint set 1). See Figure 6.12 for details. Extreme values are also registered where other geological features such as dikes occur close to the section.

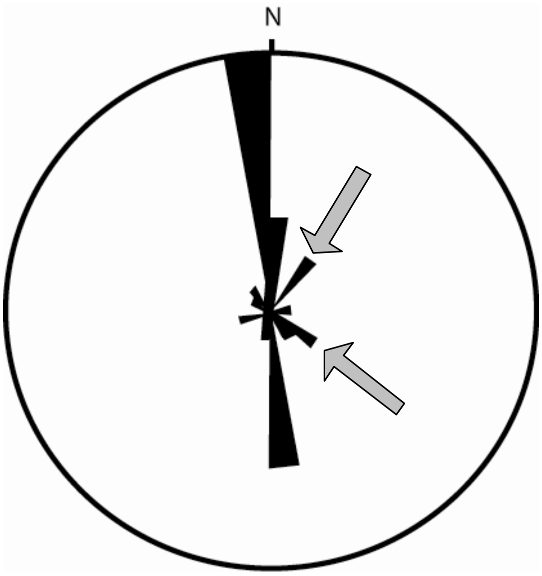


Figure 6.12: Rose diagram showing joint and fault orientations from the total section of the re-worked data. Grey arrows indicate joints 30°-45° to fault plane.

For ***faulted rock masses*** the mean value of grout take as illustrated in Table 6.1 is approximately 1100 l pr. m tunnel. These sections of the tunnel exhibit additional jointing similar to that in the other sections of the tunnel.
The increased values of grout take pr. m tunnel, as experienced for the structurally "quiet" rock, occur when joint sets 2, 3, and 4 are oriented perpendicular to the rock mass layering and/or with an angle of 30° to 45° to the strike of the layering of the rock (joint set 1). See Figure 6.12 for details. Particularly low values arise when one of the joint sets is oriented parallel to the layering of the rock. Especially high values arise close to the hanging wall of a thrust fault.

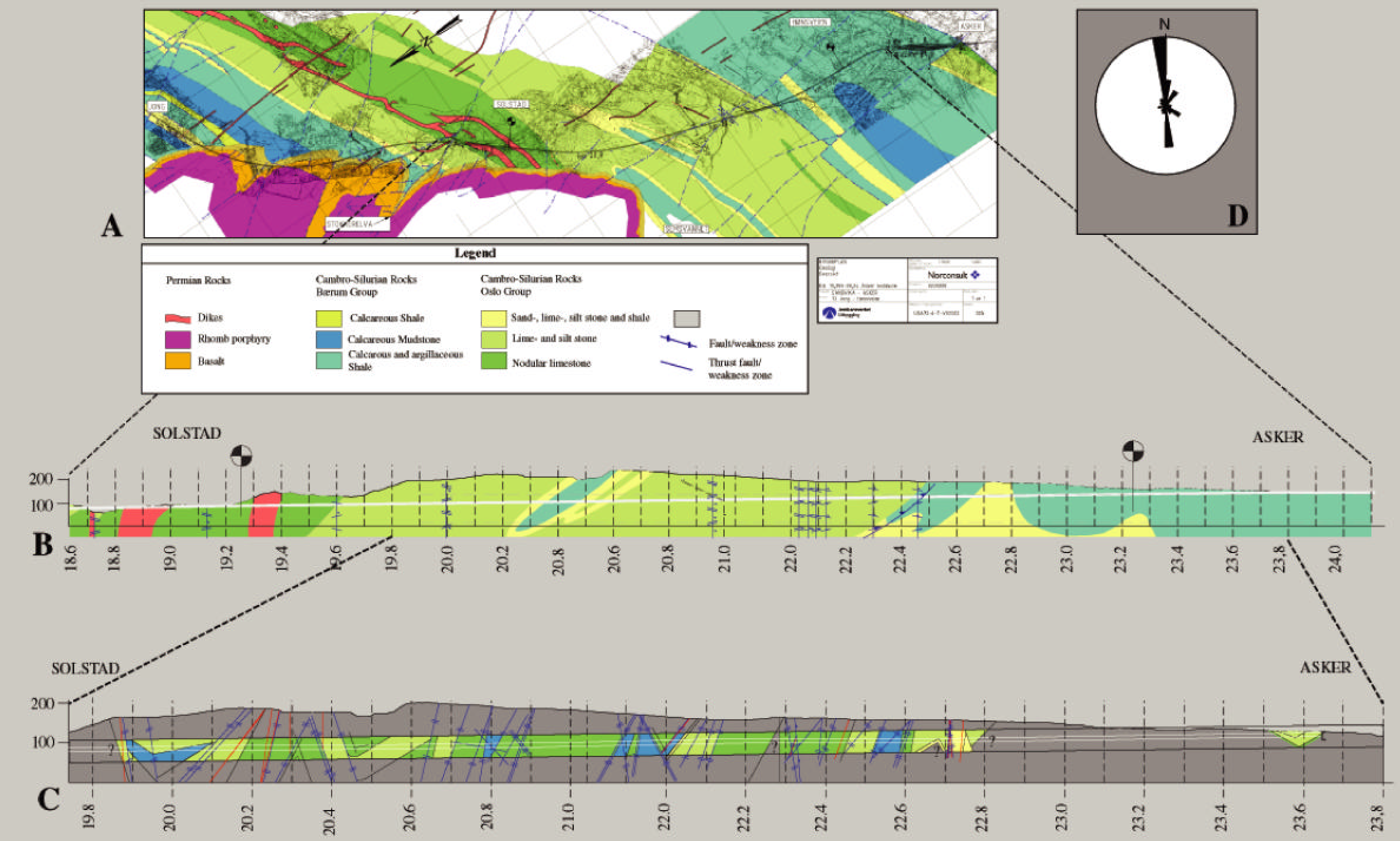
For ***folded rock masses*** the mean value as illustrated in Table 6.1 is approximately 1700 l pr. m tunnel. These sections of the tunnel exhibit additional jointing similar to that in the other sections of the tunnel.
The increased values of grout take pr. m tunnel, as experienced for the structurally "quiet" rock, occur when joint sets 2, 3, and 4 are oriented perpendicular to the rock

mass layering and/or with an angle of 30° to 45° to the strike of the layering of the rock (joint set 1).
Low values occur when one of the joint sets is oriented parallel to the layering of the rock. High values arise when the additional joint sets have orientations perpendicular to the layering of the rock.

For ***rock masses cut by dikes*** the mean value as illustrated in Table 6.1 is approximately 2500 l pr. m tunnel. These sections of the tunnel exhibit additional jointing similar to that in the other sections of the tunnel.
The increased values of grout take pr. m tunnel, as experienced for the structurally “quiet” rock, occur when joint sets 2, 3, and 4 are oriented perpendicular to the rock mass layering and/or with an angle of 30° to 45° to the strike of the layering of the rock (joint set 1). Particularly low values arise when one of the joint sets is oriented parallel to the layering of the rock whilst exceptionally high values occur when the additional joint sets have orientations perpendicular to the layering of the rock.

Figure 6.13 (Next page). The “new geologic profile” of the JA1 tunnel. (**A**) shows the original geologic Norconsult map USA72-6-T-V02002 of the area in which the JA1 and JA2 tunnels are to be constructed. (**B**) shows the original geologic Norconsult profile USA72-6-T-V02002 of the JA1 Skaugum tunnel. The JA2 Tanum tunnel is not included in this profile. (**C**) This is the new geologic profile of the JA1 Skaugum tunnel based on the data from the tunnel. The lithologies along this trace are simplified according to Sections 5.2.3 and 6.3.1. (**D**) is a rose diagram showing the orientations of joint sets 2, 3, and 4 for the total length of the JA1 tunnel, and is the same as in Figure 6.12. For additional rose diagrams of the individual sections of the tunnel see Appendix E1.

JA1 Skaugum Tunnel



Chapter 7

Discussion and conclusions

7.1 Uncertainties, limitations and simplifications

Due to the nature of the data and the procedure for how they are collected, uncertainties and limitations lie within them. Furthermore, simplifications have had to be made in order to constrain a simple geologic profile.

The following discussion of the uncertainties is not primarily in the light of the quality of the results, but is given to enhance the understanding of the process of how the data are obtained and how the procedure of re-working them may affect the results.

The uncertainties discussed below are not unique for this project.

7.1.1 Uncertainties in Q-values and corresponding parameters

Empirically derived numbers may be inaccurate and to a certain extent erroneous depending on the watchfulness of the engineering geologist on site and the time he or she may have had to map the fresh tunnel section and face. Ideally the engineering geologist has access to the roof of the tunnel to facilitate the mapping of the Q-parameters, but this has seldom been the case in the JA1 tunnel. The roof of the tunnel has to be mapped from the tunnel floor, using the face and the walls of the tunnel to retrieve all values.

The fact that for large sections of the tunnel the J_w and SRF values have been set equal to 1, limits the accuracy of the Q-value.

7.1.2 Uncertainties in orientation, dip and extent of geologic features

Geologic features, ranging from orientation and dip of the different joints to the extent of folded and faulted strata, have not been defined by a compass or a measuring stick. The features are drawn as they are perceived by extrapolating them from the tunnel to the tunnel mapping sheet without measuring their true orientation, dip or width.

The direction of movement and thereby the type of fault (normal, thrust or transverse) has not been systematically registered although some thrust faults are mapped. The magnitude and sense of relative displacement is not recorded and limits the interpretation. The “new geologic profile” is therefore simplified due to the inadequate information. The strike and dip values used in the spread sheet and for subsequent analysis have been obtained by the method described in Section 5.2.3.

7.1.3 Uncertainties and simplifications in lithologic determination

The lithologic determination during mapping has been cumbersome for some strata. Many of the stages of the Oslo Super Group (Section 2.3) are composed of similar lithologies, and this makes differentiating between them difficult. The three boreholes (K5, K6 and K7) intersecting the trace of the JA1 tunnel are far apart and to interpolate between them is difficult as the strata are tectonically reworked.
The simple test of dripping a little hydrochloric acid on a hand piece of rock to determine if the rock contains lime has not been conducted. In addition, there have been no samples sent to a laboratory for investigation to aid in the establishing of certain lithologic sequences. The lithologies composing the new geologic profile are therefore simplified compare to the stratigraphic description in Chapter 2.

7.1.4 Uncertainties within the semi-statistical analysis

The determination constant r^2 describes the correlation between the variances of the parameters plotted and according to Section 5.3.2 the constant gives the degree of correlation as a number between 1 and -1. Section 6.2 describes why the graphic presentations have been plotted for the total section of the tunnel and not as separate individual sections divided by homogeneous Q-values. The determination constant cannot be determined when very low numbers of values are plotted. On the other hand, the graphical presentations of the data from the whole section may not be representative as there may be too many variables involved which affect the potential correlation between the two parameters plotted in each diagram.

7.2 Discussion of the correlation of grout take with Q-system parameters

7.2.1 Q-value vs. grout take

The Q-value is set to describe the *stability conditions* for an excavation in a rock mass. Therefore there may not exist any direct correlation between this value and the grout take surrounding the excavation.

Very small Q-values (Chapter 4, figure 4.2) may reflect that the rock joints contain significant amounts of clay and may therefore be virtually impermeable to grout. However, the extremely low values of Q occurring in the JA1 data are of the Asker working face where the overburden is minimal, and are not a consequence of high clay content. The Q-value is small because the highly jointed rock mass is composed of several joint sets. The low Q-value therefore indicates an increase in the joint volume of the rock, enhancing the grout permeability in many cases.
There are no values higher than Q = 15 mapped in the section, but according to Figure 6.1 the trend line indicates that grout take increases with increasing Q-value, i.e grout take increases with increasing rock quality. There seems to be a drastic decrease in grout take when Q-values are less than 2.5 (this value lies within the class for poor rock quality) but an over all increase in grout take for increasing Q-values.
Unfortunately, the J_w and SRF parameters have not been mapped consistently for the remaining sections, and this therefore influences the result by yielding inaccurate calculations of the Q-value for the sections of the tunnel where there either is leakage into the tunnel or the rock is faulted in some way.
The correlation results for this parameter may therefore be disregarded.

7.2.2 RQD vs. grout take

According to the results shown in Figure 6.2, the trend line for this correlation shows an increase in the grout take with increasing RQD-value. This means that the grout permeability increases with increasing quality, i.e grout take increases with decreasing number of joints present per cubic meter of rock mass (internal jointing of the rock mass).

The results for this parameter may be disregarded as there is no correlation between the parameters and the trend line indicates a correlation which cannot be explained logically.

7.2.3 J_n vs. grout take

The indicated correlation in figure 6.3 is that the grout take increases with the increasing number of joint sets existing within the rock mass. As the number of joints sets increase so does the possibility of communication between the joints. The more joint sets the rock mass consists of, the better the communication between the joints, resulting in greater grout permeability. More grout can therefore enter the rock mass.

7.2.4 RQD/J_n vs. grout take

The trend line in Figure 6.4 indicates that as the degree of fracturing (RQD/J_n) increases, the rock mass exhibits an increase in the volume of joints, thereby also increasing the grout permeability in the rock mass.

This indicates that rock masses of good quality have much lower grout permeability than rock masses of poorer quality. It seems from this relationship that there is a marked decrease in grout take for RQD/J_n-values lower than 5.

However, due to the fact that the correlation results of the RQD-parameter have been disregarded, this parameter may also be ignored.

7.2.5 J_r vs. grout take

From Figure 6.5 it seems as if the grout take increases as the joints exhibit smoother and planar properties. This may lead to the assumption that rough and wavy joints may be less continuous and interconnected than smooth and plane joints, and thereby reduce the grout permeability.

7.2.6 J_a vs. grout take

High J_a-values correspond to joints which are weathered or with clay mineral filling (Figure 4.2, Chapter 4), and may have low hydraulic conductivity. However, on each side of a clay-filled joint the rock may be more pervious and thereby may enhance the grout take. Sections with high grout permeabilities may therefore also exhibit high values of J_a. According to Figure 6.6, the trend line shows a grout take decrease with increasing J_a-value implying that an increasing joint alteration factor corresponds to decreasing grout take. This may be interpreted to indicate that the more clay mineral filling the joint consists of, the more impervious it is to injected grout masses.

7.2.7 J_r/J_a vs. grout take

From Figure 6.7 it seems that the grout take along the trace of the tunnel stays constant with this ratio.

From the interpretation of J_r, the grout take permeability increases as the joints exhibit smoother and planar properties. This leads to the assumption that rough and wavy joints may be less continuous than smooth and plane joints and thereby reduces the grout permeability.

The interpretation of J_a says that the more clay mineral filling there is in a joint, the more impervious it is to injected grout masses.

However, the results of this correlation may be disregarded as the J_a-parameter counteracts the Q-value when calculating for tunnel support.

7.2.8 J_w vs. grout take

The J_w-value registered is the water inflow to the tunnel after injection of the grout curtain, and may aid in the explanation of why there are no measured J_w-values below $J_w = 0.66$. In addition, there are only five measurements of $J_w = 0.66$ in total, even though water inflow of < 5 l pr. min has been measured at 90 locations along the trace of the tunnel. This corresponds to a coverage of 0.6%.

Therefore, the semi-statistical analysis for this parameter and the graphic presentation of the correlation results in Figure 6.8 are not representative and may be disregarded.

7.2.9 SRF vs. grout take

In general the SRF-value for the rock mass has been set to 1 and thereby to a large extent ignoring the fact that the rock is faulted and thereby relieved of excess tectonic stresses. These areas should be mapped as SRF = 2.5 or higher. The few locations where this is taken into consideration are unfortunately not visible in the graphic presentation as they have no corresponding grout take values at that specific section. Therefore, the SRF-values for the working face toward Asker have been used.

From Figure 6.9 increasing values of SRF suggests heavier fracturing or opening of joints perpendicular to the direction of the major principle stress i.e in the direction of s_1.

This thereby increases the joint volume of the rock, and the grout permeability in that direction.

7.2.10 J_w/SRF vs. grout take

Because the J_w and SRF factors have been plotted for the shallow terrain-to-tunnel depths of the tunnel constructed from Asker, the SRF-data only include values of 2.5 and 5 (see section of SRF vs. grout take in Section 6.1.2). The J_w-value for this section of the tunnel is 1, leaving the variations in grout take solely to the value of SRF^{-1}. The SRF-values used concern surface rock conditions, and the indication shown in Figure 6.10 are that as the stress conditions (J_w/SRF) increase toward more favorable inter-locking conditions (SRF decreases toward 1), the aperture of the joints decrease rapidly resulting in a smaller joint volume and thereby lower grout permeability.

The result from this correlation should not be trusted due to the uncertainties and deficiencies connected with the mapping of the individual parameters.

7.3 Discussion of correlation of grout take with the geologic features

The results from the re-working of data with regard to structural features along the trace of the tunnel are presented in Table 6.1 (Chapter 6). The results shown in Table 6.1 indicate that grout take is increased as different geologic features intersect the trace of the tunnel compared to the grout take in between these features.

7.3.1 Lithology vs. grout take

According to Figure 6.11 grout take increases from nodular limestone (1) to interbedded sandstone (4). The increase in grout permeability in lime- and sandstone compared to nodular limestone and claystone may be a result of increased fracturing during tectonic evolution, as limestone and sandstone are more competent rocks than for example claystone. This may be a result of the following:

As tectonic evolution proceeded in the Oslo Region, most of the movement was taken up by the nodular limestone and clay and siltstone shales. There is knowledge that weaker layers tend to take up most of the deformation by internal shearing, while more competent layers are not affected to the same extent. Although nodular limestone is a fairly competent rock it consists of oriented nodules of lime in a claystone matrix, and this weaker matrix is the reason why the rock is less competent than the purer limestones. Sealing of joints as the tectonic motion proceeds may help to explain why the nodular limestone and the claystone units have lower grout permeabilities than the more competent lime- and sandstones.

7.3.2 Non-faulted rock masses

Non-faulted rock masses described in Table 6.1 corresponds to structurally "quiet" rock masses and exhibits the lowest grout take values pr. meter of tunnel compared to the other structural features. In many cases these rock masses represent sections of the rock in between sections containing folds, faults or dikes.

The mean grout take pr. m tunnel is close to 900 liters.

However, there are exceptions from this, resulting in large deviations in grout take values. Whenever the non-faulted section is in the vicinity of a geologic feature, it seems that the grout take increases by up to 0.5 - 3 times the mean grout take for structurally "quiet" rock masses. The grout take pr. m tunnel therefore depends on how close the section is to the structural feature and the lithology at the specific location.

Keeping the description of fault lineament architecture by Braathen and Gabrielsen (1998) in Section 2.5.2 in mind, the sections of the tunnel more susceptible to an increase in grout take would be the B, C and D zones to each side of the fault core of the lineament. It is therefore tempting to conclude that the increased grout take in the non-faulted rock masses is due to the presence of such zones. The highest value within the category of non-faulted rock masses represents a rock mass situated in the hanging wall of a thrust fault.

7.3.3 Faulted rock masses

Faulted rock masses described in Table 6.1 consist of masses cut by faults and the adjacent rock masses. The faulted sections exhibit the second lowest mean grout take values pr. meter of tunnel compared to the other structural features.
The mean grout take pr. m tunnel is close to 1100 liters.
As for the structurally "quiet" sections there are exceptions, once again resulting in large deviations in grout take values. For the hanging wall of thrust faults it seems that the grout take increases drastically, increasing the grout take by a factor of 8 compared to the mean value of the structurally "quiet" rock masses, and by a factor of 7 compared to the mean value for faulted masses.
From this there seems to be an indication that the hanging wall of a thrust fault requires special considerations with regards to grout take.

7.3.4 Folded rock masses

Folded rock masses described in Table 6.1 consist of folded rock masses and the adjacent rock close to the fold-hinge. The folded rock includes small scale folds observed in the tunnel and large scale, regional folds that alter the strike of the bedding planes. These sections exhibit the second highest mean grout take values pr. meter of tunnel compared to the other structural features.
The mean grout take pr. m tunnel is close to 1700 liters.
In many cases the fold-hinge exhibits the higher grout take values whilst the fold-flank somewhat less. This is due to the opening of tensile cracks normal to the fold axis during deformation.
Exceptions to the mean trend may result in large deviations in grout take values. As the folded strata suffers additional faulting the joint volume of the rock mass increases. Recalling Section 2.5.2 the general trend for many of the fold axes is that they may be

replaced by a series of joints and faults to make a weakness zone running parallel to the strike of the structure.

When competent lithologies such as sandstones suffer folding, the rock cannot yield in plastic deformation and will respond to the added tectonic forces by brittle deformation. This leads to the formation of joints perpendicular to the direction of the major principle stress s_1, i.e in the s_3 direction. The grout take in this sandstone is 7 times higher than for the mean value for structurally “quiet” rock and 3,5 times higher than for the mean value of folded rock.

Considering the above there seems to be a demand for special attention concerning grout take in the vicinity of folds in a rock mass.

7.3.5 Rock masses intercepted by dikes

Rock masses intercepted by dikes described in Table 6.1 consist of rock masses of the penetrated dikes and the adjacent rock. These sections exhibit the highest mean grout take values pr. meter of tunnel compared to the other structural features.

The mean grout take pr. m tunnel is close to 2500 liters. This is almost 3 times the mean grout take for structurally “quiet” rock and more than 2 times the mean value for faulted rock.

Dikes are composed of melted rock derived from magma chambers in the crust. These rocks have a totally different composition from the rocks they penetrate in the JA1 tunnel and also exhibit large deviations in mechanical properties compared to the surrounding rock. As the melted mass forces its way from the magma chamber through the crust, it jacks open existing zones of weakness to ease the flow through the rock in a manner that in principle resembles hydraulic fracturing. During cooling the dike fissures and thereby creates weaknesses in the rock that may be activated by subsequent tectonic activity.

Not surprisingly there are therefore exceptions to the mean grout take value. The grout take increases drastically as the dike appears in the vicinity of faults. The increase in grout take is by a factor of 2 – 2,5. According to Løset (1981b) there are several examples showing that the dikes tend to fracture heavily when they appear close to faults, and the dikes also tend to fracture more heavily than the surrounding bed rock when subjected to tectonic forces.

Taking these aspects into consideration, rock masses intercepted by dikes need special attention when a grout prognosis is made.

7.4 Discussion of joint orientation in connection to geologic features

The results in Section 6.3.2 in Chapter 6 indicate that increased values of grout take pr. m tunnel occur for all four structural features mentioned in Section 7.3, when joint sets 2, 3, and 4 are oriented perpendicular to the rock mass layering and/or with an angle of 30° to 45° to the strike of the layering of the rock (joint set 1).

Low values occur when the joint sets are oriented parallel to the layering of the rock (parallel s_3). High values arise when the additional joint sets have orientations perpendicular to the layering of the rock (i.e parallel s_1). In other words, increased values of grout take pr. m tunnel occur when the joint sets within a certain section are oriented parallel or near parallel to the North-South (s_1) direction, and /or with an angle 30° to 45° to the East-West (s_3) direction.

7.4.1 The tectonic and structural origin of joint sets in the Oslo Region

Despite the differences in grout take for the different structural geologic features along the trace of the tunnel, the increasing grout take seems to be consistent with the orientation of joint sets in all cases.

Due to the tectonic and structural geologic history of the Oslo Region, the rock masses are folded and faulted with respect to the applied tectonic forces during periods of compression and extension. Because the direction of the major principal horizontal stress (s_1) was NW-SE, fold axis and layering of bedrock and layer parallel faults are oriented perpendicular to this direction, that is, in the ENE-WSW direction.

Most of the folding took place during the development of the Caledonian Orogen in the Late Silurian whilst the development of large extensional faults and re-activation of existing zones of weakness took place later, more specifically during the Permian. Due to these two main tectonic events, the rock mass involved was deformed accordingly.

During faulting, the involved blocks of rock may move vertically compared to one another, but in most cases there is an additional horizontal component involved in the motion. Because of this horizontal component, additional jointing may occur as Enechelong tensile joints, oriented approximately 45° to the fault plane in the s_1 direction (Andresen, 2004). The addition of such tensile joints may explain why there is an increase in grout take and grout permeability where these features occur.

The fact that the extensional faulting post-dates the compressional events may aid the explanation that for folds it is not the joints parallel to the fold axis that exhibit the greatest grout permeability as described in Section 7.3.3, but the joints oriented parallel or near parallel to the North-South (s_1) direction, and /or with an angle 30° to 45° to the East-West (s_3) direction.

7.5 Conclusions

The results from Chapter 6 have been successively interpreted and discussed through Sections 7.1 to 7.4 of this chapter and lead to the following conclusions.

7.5.1 Q-value and corresponding parameters.

- There is no correlation between the Q-value and the grout take of the rock mass in the JA1 tunnel. There were inaccuracies in the determination of the Q-values and the individual parameters. This may have effected the conclusions.
- There is no correlation between any of the parameters in the Q-system and the grout take of the rock mass for the JA1 tunnel.
  There is, however, an indication that an increase in the J_n-value also increases the grout take. There is also an indication that an increase in the J_r-value decreases the grout take, and an indication that grout take decrease with increasing Ja-value exists. These results seem feasible.

Based on the results in Chapter 6 and the discussion of the results in this chapter there is little evidence to support or reject the conclusions of Bhasin (2000) that by using a modified Q_i-value one may predict the grout take.

7.5.2 Lithology, geologic features and joint orientations

There is no clear correlation between the different lithological units as they are presented in this thesis, and the grout take of the rock mass in which they occur.
There does, however, seem to be an indication toward increased grout takes in lime- and sandstones compared to nodular lime and clay stones as a result of the competence of the rock when subjected to the additional tectonic forces in the Oslo Region.
On the other hand, the presence of geologic features such as faults, folds and dikes seem to have a pronounced influence on the grout take for the section of rock mass in which they occur. Mean grout take values increase successively from structurally “quiet” rock through faulted and folded rock to rock masses intercepted by dikes. However, “special case” values occur for all features showing a variation in grout take depending on the specific conditions at different locations along the trace of the tunnel.
Joint orientations are a result of the tectonic history of the region. All geologic features gave an increased grout take when the joint sets are oriented perpendicular to or with an angle of 30° to 45° to the bedding within the rock mass. In other words, increased grout take occurs when they are oriented parallel or near parallel to the s_1 direction (NW-SE).

Chapter 8

Personal experiences and recommendations

8.1 Construction procedure

Due to the construction procedure set by the contractor there is little time for the engineering geologist to extract all the necessary information from a newly blasted length of tunnel and tunnel face before the section is for ever lost under a thick layer of shotcrete.

For the engineering geologist to obtain adequate estimations of the parameters involved in the Q-system, the he7she needs time to extract the necessary details from the working face. Being able to reveal flat lying strata or sections of potential outfall of rock is very important in the light of tunnel stability and safety.

It is my experience that access to the roof of the tunnel is rarely granted, and there is a minimal amount of time between the scaling and removal of the masses from the scaled tunnel face, to the application of shotcrete.

8.2 Q-parameters

As the new sections of the tunnel are revealed meter by meter they need to be mapped consecutively. Even if pre-grouting has taken place, all the parameters of the Q-system need to be taken into account to estimate a Q-value that in the best way reflects the conditions at that specific section.

Any leakage into the tunnel needs to be reflected in a reduced J_w parameter value even if it is a value of the leakage into a pre-grouted tunnel. Faults need to be reflected in the SRF parameter value as the rock has experienced a reduction in strength through brittle deformation due to the excess tectonic stresses.

It should be feasible to calculate two separate Q-values in sections that experience leakage or faults; one for the faulty/leaky section and one for the adjacent rock.

The Q-system consists of 6 parameters and the table for applying the Q-value to determine the support measures required (Figure 4.3), depends on those 6 parameters. By excluding parameters the calculation of safety measures may become inaccurate.

If the J_w/SRF ratio is to be eliminated from the Q-system as it stands today, the revised Q-value would not reflect the water and stress conditions of the tunnel. These will then have to be taken into account in some other way, for example in accordance with Bhasin (2000).

It is my experience that leakage and stress reduction has been largely overlooked when the engineering geologist mapped the fresh sections of the JA1 tunnel.

8.3 Lithology, joint orientation and structural features

Geologic strata need to be identified both as lithologic units to ease structural, tectonic and stratigraphic interpretation of the material the tunnel is driven through, and for the mechanical properties they exhibit.

Any stratification, faulting, folding and intersection of dikes changes the mechanical properties of the rock mass and the rock mass may behave highly anisotropic with respect to the tunnel due to these features. Additionally, the hydrogeologic properties of the rock largely depend on these conditions as water in rock is mostly transported through joints. The orientation and dip of joints and geologic features are important parameters when considering stability as well as leakage into the tunnel to be excavated.

It is my experience from the JA1 tunnel that the engineering geologist makes only a rough evaluation of the lithology and orientation of the rock joints and the structures within the rock mass, not emphasizing the importance of a closer definition of what the rock really consists of.

8.4 Future projects

In order to keep track of all the information available from a newly blasted section of the tunnel the optimal work team would be that of an engineering geologist with a technical background and an engineering geologist with a structural geologic background. In this way the team would fill each others gaps of knowledge due to the differences in educational background, so that all the necessary information would be registered.

References

- Andresen, A., 2004 ; *Personal communication at the University of Oslo.*

- Barton, N., Lien, R., and Lunde, J., 1974 ; *Engineering classification of rock masses for the design of tunnel support.* Rock Mechanics v. 4, pp.189-236.

- Barton, N., 1995 ; *The influence on joint properties in modelling jointed rock masses.* Keynote lecture, 8th Congress of ISRM, Tokyo, v. 3. Rotterdam: Balkema.

- Barton, N. 2000 ; *TBM Tunnelling in Jointed and Faulted Rock.* A.A. Balkema

- Barton, N., 2002 ; *Some new Q-value correlations to assist in characterisation and tunnel design.* International Journal of Rock Mechanics & Mining Sciences, v. 39, pp. 185-216.

- Barton, N., Buen, B., Roald, S, 2002 ; *Strengthening the case for Grouting.* Tunnels and Tunnelling International, pp. 37-39.

- Bhasin, R. 2002 ; *Frøyatunnelen – Vurdering av injeksjon i forhold til Q-parametere.* Miljø- og samfunnstjenelige tunneler. NGI Report 20001042-1, 37p.

- Bieniawski, Z. T., 1974 ; *Geomechanics classification of rock masses for the design of tunnel support.* Proc. 3rd. Cong. ISRM (Denver), v. 2A, 27p.

- Bieniawski, Z. T., 1989 *; Engineering rock mass classifications: a complete manual for engineers and geologists in mining, civil and petroleum engineering.* New York: Wiley, 251p.

- Braathen, A. and Gabrielsen, R. 1998 *; Lineament architecture and fracture distribution in metamorfhic and sedimentary rocks, with application to Norway.* NGU-Report no. 98.043, 78p.

- Churchman, C. W., 1948 ; *Theory of experimental inference.* Macmillan, New York. pp.2

- Dons, J. A., Gyøry, E., 1967 ; *Permian sediments, lavas and faults in the Kolsås area west of Oslo.* Norsk Geologisk Tidsskrift 47, pp. 57-77.

- Dons, J. A., Larsen, B. T., 1978 ; *The Oslo Paleorift: A review and guide to excursions.* NGU Bulletin 337, 199p.

- Domenico, P. A., and Schwartz, F. W., 1990 ; *Physical and Chemical Hydrogeology, Second Editon.* John Wiley and Sons, Inc. 506p.

- Engelder, T., 1993 ; *Stressregimes in the lithosphere.* Princeton Univ. Press, pp. 66.

- Fetter, C. V., 1994 ; *Applied Hydrogeology, Fourth Edition.* Prentice hall, Inc. Upper Saddle River, New Jersey, 598p.

- Freeze, R. A. and Cherry, J. A., 1979 ; *Groundwater.* Prentice hall, Inc. Englewood Cliffs, New Jersey, 604p.

- Goodmann, R. E., 1989 ; *Introduction to Rock Mechanics*, 2nd edition. Wiley, Toronto. 562p.

- Gradstein, F. M. and Ogg, J. G 1996 : *A Phanerozoic Time Scale.* Episodes 1996, volume 19, no's 1.2, Saga Petroleum.

- Grimstad, E., Barton, N., 1993 ; *Sprayed Concrete - Modern use for underground Support.* Eds. Kompen, Oftedal, Berg, Proceedings of the International Symposium on Sprayed Concrete. Fagernes, Norway, Norwegian Concrete Association.

- Johansen, P. M., 2002 ; *Inflow criteria for a railway tunnel in the greater Oslo area.* Norwegian Tunnelling Society v. 12, pp. 59-63.

- Karlsrud, K., 2002 *; Control of water leakage when tunnelling under urban areas in the Oslo Region.* Norwegian Tunnelling Society v.12, pp. 27-33.

- Larsen, B. T., Olaussen, S., Bockelie, J. F., Worsley, D., Gabrielsen, R. H., 1995 ; *Sedimentology and tectonics of the Oslo Graben: A guide to excursions*.

- Lutro, O., Nordgulen, Ø., Braathen, A., 1999 ; *Geologiske forhold langs jernbanetrasè Asker-Sandvika*. NGU-Report no. 99.011, 6p.

- Løset, F., 1981a *; Analyse av injeksjonsrsultater fra VEAS-tunnelen*. NTNF Prosjekt no. 25141, 43p.

- Løset, F., 1981b ; *Ingeniørgeologiske erfaringer fra kloakktunnelen Lysaker-Slemmestad.* NGI-Report

- Løset, F.,1991 ; *Sammenheng mellom injeksjonsresultater og geologi i tunneler i Oslo-området.* NGI-Report no.548150-4, 22p.

- Løset, F, 1997 ; *Praktisk bruk av Q-metoden.* NGI-Report no.592046-2, 43p.

- Marques, A, 2003 ; *Evaluation of the impact of the Jong-Asker Tunnel to private wells in the Lagerudbekken area.* Assignment for course G-GF350: Groundwater modelling and contaminant transport, UiO, Norway, 16p.

- Nilsen, B., and Thideman, A., 1993 ; *Rock Engineering.* Hydropower Development, vol. no. 9. Norwegian Institute of Technology, division of Hydraulic Engineering. Tapir, 156p.

- Nilsen, O., 2004 ; Personal communication at the Department of Geosciences, University of Oslo, Oslo, Norway.

- Norconsult, 2000 ; *Nytt dobbeltspor Asker-Skøyen. Parsell Jong-Asker. Ingeniørgeologisk Rapport.* Norconsult Report, 38p.

- Norconsult, 2000a ; *Nytt dobbeltspor Asker-Skøyen. Parsell Jong-Asker. Fagrapport Hydrogeologi.* Norconsult Report, 47p.

- Nordgulen, Ø., Lutro, O., Solli, A., Roberts, D., Braathen, A.,1998 *; Geologisk og strukturgeologisk kartlegging for Jernbaneverket Utbygging i Asker og Bærum.* NGU-Report no. 98.124, 27p.

- Oftedal, C., 1981 ; *En oversikt over Norges regional geologi*, 2. ed. Tapir, Trondheim, pp 72-78 and 185-193.

- Olaussen, S., Larsen, B. T., Steel, R., 1994 ; *The upper Carboniferous-Permian Oslo Rift; Basin fill in relation to tectonic development.* Canadian Society of Petroleum Geologists, Memoir 17, p. 175-197.

- Owen, A. W., Bruton, D. L., Bockerlie, J. F., Bockerlie, T. G., 1990 ; *The Ordovician Succession of the Oslo Region.* NGU Special Publication 4, 54p.

- Palmstrøm, A., 1982 ; *The volumetric joint count – a useful and simple measure of the degree of jointing.* Proceedings IV International Congress, IAEG, New Delhi, V.221-V.228.

- Ramberg, I. B., Gabrielsen, R. H., Larsen, B. T., Solli, A., 1977 ; *Analysis of fracture pattern in Southern Norway.* Geologij en Mijnbouw 56, pp. 295-310.

- Roald, S., Barton, N. and Nomeland, T., 2002 ; *Grouting - The third leg of underground construction*. Norwegian tunnelling Society v. 12, pp. 75-80.

- Sundvoll, B., Neumann, E. R., Larsen, B. T., and Tuen, E. 1990 ; *Age relations among Oslo Rift magmatic rocks.* Tectonophysics 178, pp. 67-78.

- Sæther, E., 1947 ; *Studies of the igneous rock complex of the Oslo region VIII. The dykes in the Cambro-Silurian rocks of Bærum.* Norske vitenskapsakademi i Oslo, in: Mat.-Naturvid. Kl. 1947, v.3, 60p.

- Worsley, D., Aarhus, N., Basset, M. G., Howe, M. P. A., Mørk, A., Olaussen, S., 1983 ; *The Silurian Succession of the Oslo Region*. NGU Bulletin 384, 57p.

- www.kvasir.no, 2003 : Electronic map of Norway and the Oslo area.

Appendix A
Compilation spread sheet
Total section

Data compilation Total Section.															
Pel no.	**Grout take (L)**	**Leakage (L)**	**Q´- value**	**RQD**	**Jn**	**Jr**	**Ja**	**Jw**	**SRF**	**RQD / Jn**	**Jr / Ja**	**Geology**		**Comment**	**Layering strike/dip**
19867	9016,2		5,8	70	6	2	3	1	1	11,7	0,5	Nodular Limestone	1	"	set 1: 075/60 set 2: 163/70 set 3: 215/85
19874			4,4	80	6	1	3	1	1	13,3	0,33	Nodular Limestone	1	"	set 1: 070/45 set 2: 163/70 set 3: 215/85
19885	25098	24	5,4	65	6	2	3	1	1	10,8	0,5	Claystone	2	Fault! 163/70 5m, diabase 215/85 40cm wide	set 1: 075/45 set 2: 179/85
19890			9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 075/45 set 2: 359/85
19895			9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 075/45 set 2: 359/85
19901	31966	15	9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 075/45 set 2: 359/85
19907			9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 075/30 set 2: 359/85
19911			14,1	75	4	2	2	1	1	18,8	0,75	Claystone	2		set 1: 075/30 set 2: 359/85
19917	19120	18	9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 075/30 set 2: 359/85
19923			8,8	70	6	2	2	1	1	11,7	0,75	Claystone	2		set 1: 064/30 set 2: 100/85
19929			9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 064/30 set 2: 100/85
19934	26294	185	8,8	70	6	2	2	1	1	11,7	0,75	Claystone	2		set 1: 064/30 set 2: 100/85
19950	29322	227	4,7	75	6	2	4	1	1	12,5	0,38	Claystone	2		set 1: 250/05 set 2: 148/70
19960			18,8	75	4	2	2	1	1	18,8	1	Limestone	3	" 30 cm clay zone 167/80 Fault!	set 1: 250/05 set 2: 148/70
19966	28003	170,5	6,3	75	6	2	4	1	1	12,5	0,5	Limestone	3	"	set 1: 250/05 set 2: 148/90
19972			12,5	75	6	2	2	1	1	12,5	1	Limestone	3	clay filled fractures/fault 167/ 80 30cm wide	set 1: 250/05 set 2: 148/90 set 3: 030/90
19978			9,4	75	6	2	2	1	1	12,5	0,75	Limestone	3		set 1: 250/05 set 2: 148/90
19984	27205	314	14,2	85	6	2	2	1	1	14,2	1	Limestone	3		set 1: 250/05 set 2: 148/90
19989			13,3	80	6	2	2	1	1	13,3	1	Limestone	3		set 1: 250/05 set 2: 148/80 set 3: 025/90
19995			13,3	80	6	2	2	1	1	13,3	1	Limestone	3		set 1: 250/10 set 2: 148/80 set 3: 025/90
20000	30214	193										Limestone	3		set 1: 250/20 set 2: 070/70 set 3: 173/90
20005			15,0	80	4	2	2	1	1	20	0,75	Limestone	3		set 1: 250/20 set 2: 070/70 set 3: 320/90
20011			11,7	70	6	2	2	1	1	11,7	1	Limestone	3		set 1: 250/20 set 2: 070/70 set 3: 173/90 set 4: 300/15
20017	16008	71	12,5	75	6	2	2	1	1	12,5	1	Limestone	3		set 1: 250/20 set 2: 070/70 set 3: 173/90 set 4: 300/15
20022			10,8	65	6	2	2	1	1	10,8	1	Limestone	3		set 1: 250/40 set 2: 150/80 set 3: 205/45

20027			10,0	60	6	2	2	1	1	10	1	Claystone	2		set 1: 250/20 set 2: 150/80 set 3: 025/45 set 4: 205/45
20032	9474,2	8,5	11,7	70	6	2	2	1	1	11,7	1	Claystone	2		set 1: 250/20 set 2: 207/10
20039			15,0	60	4	2	2	1	1	15	1	Claystone	2		set 1: 250/20 set 2: 329/90
20044			15,0	60	4	2	2	1	1	15	1	Claystone	2	Calcite layer ll	set 1: 250/20 set 2: 329/90
20048	8661,3	121,5	10,8	65	6	2	2	1	1	10,8	1	Claystone	2		set 1: 250/20 set 2: 329/90
20060			8,3	75	6	2	3	1	1	12,5	0,67	Claystone	2		set 1: 250/30 set 2 :329/90
20065	19867	22										Claystone	2		set 1: 250/30 set 2 :329/90
20071			9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 250/30 set 2 :329/90
20077			8,8	70	6	2	2	1	1	11,7	0,75	Claystone	2		set 1: 250/30 set 2 :329/90
20081	24150	46	9,4	75	6	2	2	1	1	12,5	0,75	Limestone	3		set 1: 250/30 set 2 :329/90
20088			9,4	75	6	2	2	1	1	12,5	0,75	Limestone	3		set 1: 250/45 set 2: 320/90
20094			4,4	70	6	2	4	1	1	11,7	0,38	Limestone	3	Fault layer ll	set 1: 250/45
20097	10898	40										Limestone	3	"	set 1: 250/45
20101			4,4	70	6	2	4	1	1	11,7	0,38	Limestone	3	"	set 1: 254/50 set 2: 350/90
20107			9,4	75	6	2	2	1	1	12,5	0,75	Limestone	3	Fault ll layer dip 45	set 1: 254/50 set 2: 000/80 set 3: 032/60
20112	14034	65,5	5,8	70	6	2	3	1	1	11,7	0,5	Limestone	3		set 1: 254/50 set 2: 350/90
20117			9,4	75	6	1,5	2	1	1	12,5	0,75	Limestone	3		set 1: 254/50 set 2: 350/90
20123			8,8	70	6	1,5	2	1	1	11,7	0,75	Limestone	3		set 1: 254/50 set 2: 350/90
20130	17040	145	8,8	70	6	1,5	2	1	1	11,7	0,75	Limestone	3		set 1: 254/50 set 2: 350/90
20146	26942	167	8,8	70	6	2	2	1	1	11,7	0,75	Limestone	3		set 1: 254/50 set 2: 350/90
20152			5,8	70	6	2	3	1	1	11,7	0,5	Limestone	3		set 1: 254/50 set 2: 350/90
20157			5,8	70	6	2	3	1	1	11,7	0,5	Limestone	3		set 1: 254/50 set 2: 008/80
20163	21105		6,3	75	9	2	2	1	1	8,33	0,75	Limestone	3	dike layer ll	set 1: 258/50 set 2: 190/90 set 3: 008/30
20168			4,2	75	9	2	3	1	1	8,33	0,5	Limestone	3		set 1: 258/50 set 2: 190/90 set 3: 008/30
20173	350		4,2	75	9	2	3	1	1	8,33	0,5	Limestone	3		set 1: 258/50 set 2: 190/90 set 3: 008/30
20178	36436	119,5	9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1		set 1: 258/50 set 2: 190/90 set 3: 008/30 set 4: 248/70
20185			9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1		set 1: 258/60 set 2: 190/50
20190	460		11,7	70	6	2	2	1	1	11,7	1	Nodular Limestone	1		set 1: 258/60 set 2: 190/50
20196	21353		13,3	80	6	2	2	1	1	13,3	1	Nodular Limestone	1	clay filled fracture ll layering	set 1: 252/80 set 2: 091/60
20201			12,5	75	6	2	2	1	1	12,5	1	Nodular Limestone	1		set 1: 252/80 set 2: 091/60
20207	546,3		9,4	75	6	2	2	1	1	12,5	0,75	Nodular	1		set 1: 252/80 set 2: 091/60

												Limestone			
20213	32456		9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1		set 1: 254/50 set 2: 172/70
20218			8,8	70	6	2	2	1	1	11,7	0,75	Nodular Limestone	1		set 1: 254/50 set 2: 172/70
20222	565		10,6	85	6	2	2	1	1	14,2	0,75	Nodular Limestone	1		set 1: 254/50 set 2: 172/70 set 3: 095/60
20229	9447,5		6,3	75	6	2	3	1	1	12,5	0,5	Nodular Limestone	1		set 1: 254/50 set 2: 172/70 set 3: 095/60
20234			9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1	dike 354/80 clay 095/60	set 1: 254/50 set 2: 172/70 set 3: 095/60
20239	1459,4		5,8	70	6	2	3	1	1	11,7	0,5	Nodular Limestone	1		set 1: 254/70
20245			6,3	75	6	2	3	1	1	12,5	0,5	Nodular Limestone	1		set 1: 254/70
20250	16245	26	5,8	70	6	2	3	1	1	11,7	0,5	Nodular Limestone	1	Dike 352/70 cut by fault 261/75	set 1: 254/70
20256	640		3,9	70	9	2	3	1	1	7,78	0,5	Nodular Limestone	1		set 1: 254/70
20262	12916	34	6,3	75	6	2	3	1	1	12,5	0,5	Nodular Limestone	1		set 1: 254/70
20268			6,3	75	6	2	3	1	1	12,5	0,5	Nodular Limestone	1		set 1: 254/70
20274	369,3		5,8	70	6	2	3	1	1	11,7	0,5	Nodular Limestone	1		set 1: 254/70
20280	12715	6										Nodular Limestone	1		set 1: 254/70
20284			6,3	75	6	2	3	1	1	12,5	0,5	Nodular Limestone	1		set 1: 254/70
20290	381,1		5,8	70	6	2	3	1	1	11,7	0,5	Nodular Limestone	1		set 1 :255/60 set 2: 120/90
20295	17534	5,5	5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1	dike 031/90	set 1 :255/60 set 2: 120/90
20302			5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1		set 1 :255/60 set 2: 120/90
20307	859,1		9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1	Fault 255/60	set 1: 255/60
20312	23992	10,5	5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1		set 1: 255/60
20317			8,8	70	6	2	2	1	1	11,7	0,75	Nodular Limestone	1		set 1: 255/60
20323	232,1		5,0	60	6	2	3	1	1	10	0,5	Nodular Limestone	1	center fold axis 254/60	set 1: 083/70 set 2: 122/90

20328			4,6	55	6	2	3	1	1	9,17	0,5	Nodular Limestone	1		set 1: 083/70 set 2: 122/90
20333	17497	205	7,5	60	6	2	2	1	1	10	0,75	Nodular Limestone	1		set 1: 083/70 set 2: 122/90
20339	3203,4	12	4,6	55	6	2	3	1	1	9,17	0,5	Nodular Limestone	1		set 1: 083/70 set 2: 122/90
20344			4,6	55	6	2	3	1	1	9,17	0,5	Nodular Limestone	1		set 1: 083/70 set 2: 122/90
20350	20277	389	4,6	55	6	2	3	1	1	9,17	0,5	Nodular Limestone	1		set 1: 083/70 set 2: 122/90
20355			4,2	50	6	2	3	1	1	8,33	0,5	Nodular Limestone	1		set 1: 083/70 set 2: 122/90
20361			4,6	55	6	2	3	1	1	9,17	0,5	Nodular Limestone	1		set 1: 083/70 set 2: 122/90
20366	6878,8	73	4,2	50	6	2	3	1	1	8,33	0,5	Nodular Limestone	1		set 1: 083/70 set 2: 122/90
20372			3,8	60	6	2	4	1	1	10	0,38	Nodular Limestone	1	" "	set 1: 083/70 set 2: 122/90
20377	10475	18	5,4	65	9	2	2	1	1	7,22	0,75	Limestone	3	" Fault 083/50	set 1: 083/70
20384			5,4	65	9	2	2	1	1	7,22	0,75	Limestone	3	dike 335/90 0,2m	set 1: 083/70
20389	633,8		3,3	60	9	2	3	1	1	6,67	0,5	Limestone	3		set 1: 083/70
20395	7077,3	5										Limestone	3		set 1: 083/70
20405	666		4,6	55	6	2	3	1	1	9,17	0,5	Limestone	3		set 1: 083/70
20411	10940		5,0	60	6	2	3	1	1	10	0,5	Limestone	3		set 1: 083/70
20418	257		5,4	65	6	2	3	1	1	10,8	0,5	Limestone	3		set 1: 083/70
20423			7,5	60	6	2	2	1	1	10	0,75	Limestone	3		set 1: 083/70
20429	1133,6		4,6	55	6	2	3	1	1	9,17	0,5	Limestone	3		set 1: 083/70
20435			4,2	50	6	2	3	1	1	8,33	0,5	Limestone	3	"	set 1: 083/70
20440			7,5	60	6	2	2	1	1	10	0,75	Limestone	3	Fault layer ll	set 1: 082/70 set 2: 176/90
20445	595,2		7,5	60	6	2	2	1	1	10	0,75	Nodular Limestone	1		set 1: 082/70 set 2: 176/90
20452	31991	11	5,6	50	6	2	3	1	1	8,33	0,67	Nodular Limestone	1		set 1: 082/70 set 2: 176/90
20457			8,8	70	6	2	2	1	1	11,7	0,75	Nodular Limestone	1		set 1: 082/70 set 2: 176/90
20463	1636,4	0,4	5,0	60	6	2	3	1	1	10	0,5	Nodular Limestone	1		set 1: 082/70 set 2: 176/90
20469	13863	145	5,4	65	6	2	2	1	1	10,8	0,75	Nodular Limestone	1	center fold axis	set 1: 251/10
20474			7,5	60	6	2	2	1	1	10	0,75	Nodular	1		set 1: 251/20

												Limestone			
20479			5,8	70	9	2	2	1	1	7,78	0,75	Nodular Limestone	1		set 1: 251/20
20485	3292,9	21	6,3	75	9	2	2	1	1	8,33	0,75	Nodular Limestone	1		set 1: 250/30 set 2: 176/85 set 3: 060/60
20490	54483	860	4,2	75	9	2	3	1	1	8,33	0,5	Nodular Limestone	1		set 1: 250/30 set 2: 176/85 set 3: 060/60
20495			4,4	80	9	2	3	1	1	8,89	0,5	Nodular Limestone	1		set 1: 250/30 set 2: 176/85
20501			3,6	65	9	2	3	1	1	7,22	0,5	Nodular Limestone	1		set 1: 250/30 set 2: 176/85
20507	7831,2	16	3,9	70	9	2	3	1	1	7,78	0,5	Nodular Limestone	1		set 1: 250/30 set 2: 176/85
20512	14765	548	3,9	70	9	2	3	1	1	7,78	0,5	Limestone	3		set 1: 250/30 set 2: 176/85
20518			5,8	70	6	2	3	1	1	11,7	0,5	Limestone	3		set 1: 250/30 set 2: 176/85
20524			6,3	75	6	2	3	1	1	12,5	0,5	Limestone	3		set 1: 250/30 set 2: 130/90
20529	4608	13	6,3	75	6	2	3	1	1	12,5	0,5	Limestone	3		set 1: 250/30 set 2: 130/90
20535	25136	87	8,1	65	6	2	2	1	1	10,8	0,75	Limestone	3		set 1: 250/30 set 2: 130/90
20541			6,9	55	6	2	2	1	1	9,17	0,75	Limestone	3		set 1: 250/30 set 2: 130/90
20547			7,5	60	6	2	2	1	1	10	0,75	Limestone	3		set 1: 250/30 set 2: 130/90
20551	765,3	55,5										Limestone	3		set 1: 250/30 set 2: 130/90
20552			8,1	65	4	2	3	1	1	16,3	0,5	Limestone	3		set 1: 250/30 set 2: 130/90
20556	10671	50	5,0	60	6	2	3	1	1	10	0,5	Limestone	3		set 1: 250/30 set 2: 130/90
20563			8,8	70	6	2	2	1	1	11,7	0,75	Limestone	3		set 1: 255/30 set 2: 120/85
20569			9,4	75	6	2	2	1	1	12,5	0,75	Limestone	3		set 1: 255/30 set 2: 120/85
20573	585,9		5,0	60	6	2	3	1	1	10	0,5	Limestone	3		set 1: 255/30 set 2: 120/85
20579	15321	7	9,4	75	6	2	2	1	1	12,5	0,75	Limestone	3		set 1: 255/30 set 2: 120/85
20585			5,8	70	6	2	3	1	1	11,7	0,5	Limestone	3		set 1: 255/30 set 2: 120/85
20591			7,1	85	6	2	3	1	1	14,2	0,5	Limestone	3		set 1: 255/30 set 2: 355/75-90
20595	1458		5,0	60	6	2	3	1	1	10	0,5	Limestone	3		set 1: 255/30 set 2: 355/75-90
20602	12016	23	3,8	60	6	2	4	1	1	10	0,38	Limestone	3		set 1: 255/30 set 2: 355/75-90
20607			3,1	50	6	2	4	1	1	8,33	0,38	Limestone	3	"	set 1: 255/30 set 2: 355/75-90
20613			3,1	50	6	2	4	1	1	8,33	0,38	Limestone	3	Fault layer ll dip 60	set 1: 255/30 set 2: 355/75-90
20618	408		5,4	65	6	2	3	1	1	10,8	0,5	Nodular Limestone	1		set 1: 255/30 set 2: 355/75-90
20623	23065	2										Nodular Limestone	1		set 1: 255/30 set 2: 355/75-90
20624			3,1	55	9	2	3	1	1	6,11	0,5	Nodular	1	1m diabase 255/60	set 1: 255/30 set 2: 355/75-90

												Limestone			
20629			3,1	55	9	2	3	1	1	6,11	0,5	Nodular Limestone	1		set 1: 255/30
20634			2,5	45	9	2	3	1	1	5	0,5	Nodular Limestone	1		set 1: 255/30
20640	1924,6	4	2,5	45	9	2	3	1	1	5	0,5	Nodular Limestone	1		set 1: 255/30
20643			0,1	10	15	1	6	1	1	0,67	0,17	Nodular Limestone	1	3 m wide fault 247/ 80	set 1: 255/75 set 2: 355/90
20646	19644	54										Nodular Limestone	1		set 1: 255/75 set 2: 355/90
20649			10,0	80	6	2	2	1	1	13,3	0,75	Nodular Limestone	1		set 1: 255/75 set 2: 355/90
20655			6,7	80	6	2	3	1	1	13,3	0,5	Nodular Limestone	1		set 1: 255/75 set 2: 355/90
20661	3077,5	49,1	4,7	75	6	2	4	1	1	12,5	0,38	Nodular Limestone	1		set 1: 255/75 set 2: 355/90
20667	10124	100	5,4	65	6	2	3	1	1	10,8	0,5	Nodular Limestone	1		set 1: 255/75 set 2: 355/90
20673			3,8	60	6	2	4	1	1	10	0,38	Limestone	3		set 1: 255/75 set 2: 355/90
20678			5,4	65	6	2	3	1	1	10,8	0,5	Limestone	3	clay filled fractures 300/50	set 1: 255/75 set 2: 355/90
20684			5,4	65	6	2	3	1	1	10,8	0,5	Limestone	3	calcite ll layering	set 1: 255/75 set 2: 355/90
20690	2998					2		1	1			Limestone	3		set 1: 255/75 set 2: 355/90
20696			8,1	65	6	2	2	1	1	10,8	0,75	Limestone	3		set 1: 255/75 set 2: 355/90
20701			7,8	70	6	2	3	1	1	11,7	0,67	Limestone	3	Fault ll layering	set 1: 255/75 set 2: 355/90
20707			5,0	60	6	2	3	1	1	10	0,5	Limestone	3	Fault ll set 1 0,2m	set 1: 255/75 set 2: 355/90
20713			7,8	70	6	2	3	1	1	11,7	0,67	Limestone	3		set 1: 255/75 set 2: 355/90
20719			6,7	60	6	2	3	1	1	10	0,67	Limestone	3		set 1: 255/75 set 2: 355/90
20722	7094,5											Limestone	3		set 1: 255/75 set 2: 355/90
20724			8,9	80	6	2	3	1	1	13,3	0,67	Limestone	3		set 1: 260/60 set 2: 200/90 set 3: 330/90
20730			10,0	60	6	2	2	1	1	10	1	Nodular Limestone	1		set 1: 260/60 set 2: 200/90 set 3: 330/90
20735	10288		9,2	55	6	2	2	1	1	9,17	1	Nodular Limestone	1		set 1: 260/60 set 2: 200/90 set 3: 330/90
20740			10,8	65	6	2	2	1	1	10,8	1	Nodular Limestone	1		set 1: 260/60 set 2: 200/90 set 3: 330/90
20746			6,7	60	6	2	3	1	1	10	0,67	Nodular Limestone	1		set 1: 260/70
20753	406,3		5,6	50	6	2	3	1	1	8,33	0,67	Nodular	1		set 1: 260/70 set 2: 034/10

												Limestone			
20756	4053,2	17										Nodular Limestone	1	clay filled fractures layer ll	set 1: 260/70 set 2: 034/10
20758			6,1	55	6	2	3	1	1	9,17	0,67	Nodular Limestone	1		set 1: 260/70 set 2: 034/10
20763			6,7	60	6	2	3	1	1	10	0,67	Nodular Limestone	1		set 1: 260/70 set 2: 034/10 set 3: 350/?
20769	3159,6											Nodular Limestone	1	"	set 1: 260/70 set 2: 034/10
20769			8,9	80	6	2	3	1	1	13,3	0,67	Nodular Limestone	1	fault ~260/60 clay + ll set 2	set 1: 260/80 set 2: 034/10
20775	8827,4	30	6,7	60	6	2	3	1	1	10	0,67	Nodular Limestone	1		set 1: 260/80 set 2: 034/10
20780			6,7	60	6	2	3	1	1	10	0,67	Nodular Limestone	1		set 1: 260/80 set 2: 106/90
20786	1702,2	28	5,6	50	6	2	3	1	1	8,33	0,67	Claystone	2		set 1: 260/80 set 2: 034/10
20791	13541	90	6,1	55	6	2	3	1	1	9,17	0,67	Claystone	2	fault layer ll 3m	set 1: 260/60 set 2: 350/80 set 3: 118/45
20796			6,1	55	6	2	3	1	1	9,17	0,67	Claystone	2		set 1: 260/60 set 2: 350/80 set 3: 118/45
20801			4,4	40	6	2	3	1	1	6,67	0,67	Claystone	2		set 1: 260/60 set 2: 350/80
20806	1589,2		4,1	37	6	2	3	1	1	6,17	0,67	Claystone	2	Fault 093/45	set 1: 260/60 set 2: 350/80 set 3: 093/45
20812	18032	76	4,4	40	6	2	3	1	1	6,67	0,67	Claystone	2		set 1: 260/60 set 2: 350/80 set 3: 118/60
20818			5,0	45	6	2	3	1	1	7,5	0,67	Nodular Limestone	1		set 1: 260/60
20824	454,6		5,0	45	6	2	3	1	1	7,5	0,67	Nodular Limestone	1		set 1: 260/50
20830	15580	90	5,0	45	6	2	3	1	1	7,5	0,67	Nodular Limestone	1		set 1: 260/50
20835			3,3	45	9	2	3	1	1	5	0,67	Nodular Limestone	1		set 1: 260/50 set 2: 350/90
20840			3,7	50	9	2	3	1	1	5,56	0,67	Nodular Limestone	1		set 1: 260/50 set 2: 350/90
20846			3,7	50	9	2	3	1	1	5,56	0,67	Nodular Limestone	1		set 1: 260/60
20851	11940		3,3	45	9	2	3	1	1	5	0,67	Nodular Limestone	1		set 1: 260/60
20857			2,8	50	9	2	3	1	1	5,56	0,5	Nodular Limestone	1	fault layer ll	set 1: 260/60 set 2: 170/80
20862			5,6	50	9	2	2	1	1	5,56	1	Nodular Limestone	1		set 1 :255/70 set 2: 170/80
20867			4,2	50	9	2	2	1	1	5,56	0,75	Nodular Limestone	1		set 1 :255/70 set 2: 170/80

20873	2584,5		5,6	50	9	2	2	1	1	5,56	1	Nodular Limestone	1		set 1 :255/70 set 2: 170/80
20879			8,3	50	6	2	2	1	1	8,33	1	Nodular Limestone	1	Fault! 075/50	set 1 :255/70 set 2: 170/80
20885			9,2	55	6	2	2	1	1	9,17	1	Nodular Limestone	1	Fault! 082/50	set 1 :255/70 set 2: 170/80
20890	6837,8											Nodular Limestone	1		set 1 :255/70 set 2: 170/80
20901			6,1	55	6	2	3	1	1	9,17	0,67	Nodular Limestone	1	calcite ll set 2	set 1 :255/70 set 2: 170/80
20906	5248,9		6,1	55	6	2	3	1	1	9,17	0,67	Nodular Limestone	1	Fault 170/85 ll tunnel trace	set 1: 254/70
20911	7183,2	2	5,6	50	6	2	3	1	1	8,33	0,67	Nodular Limestone	1	clay filled fractures/fault 255/60	set 1: 254/70
20918			8,3	50	6	2	2	1	1	8,33	1	Nodular Limestone	1		set 1: 254/70
20925	445	25	7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1		set 1: 255/70 set 2: 149/30
20928			7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1		set 1: 255/70 set 2: 149/30
20933	5665												1	clay filled fractures layer ll	set 1: 255/70 set 2: 149/30 set 3: 255/30
20939			5,8	35	6	2	2	1	1	5,83	1	Nodular Limestone	1		set 1: 255/70 set 2: 255/30
20944			5,0	30	6	2	2	1	1	5	1	Nodular Limestone	1		set 1: 255/70 set 2: 255/30
20949	16876												1		set 1: 255/70 set 2: 255/30
20955			4,4	40	6	2	3	1	1	6,67	0,67	Nodular Limestone	1		set 1: 255/70 set 2: 350/80
20958			4,4	40	6	2	3	1	1	6,67	0,67	Nodular Limestone	1		set 1: 255/70 set 2 350/80
20965			4,4	40	6	2	3	1	1	6,67	0,67	Nodular Limestone	1		set 1: 248/80 set 2: 350/80
20967			6,7	40	6	2	2	1	1	6,67	1	Nodular Limestone	1		set 1: 248/80 set 2: 350/80
20970	1267,1		5,0	45	6	2	3	1	1	7,5	0,67	Nodular Limestone	1		set 1: 248/80 set 2: 350/80
20977			5,0	30	6	2	2	1	1	5	1	Nodular Limestone	1		set 1: 248/80 set 2: 350/80
20982			6,7	40	6	2	2	1	1	6,67	1	Nodular Limestone	1		set 1: 248/80 set 2: 350/80
20987			6,7	40	6	2	2	1	1	6,67	1	Nodular Limestone	1	calcite ll set 2	set 1: 248/80 set 2: 350/80

20993	1045,8		7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1		set 1: 248/80 set 2: 350/80
20998			10,0	60	6	2	2	1	1	10	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21764			10,0	60	6	2	2	1	1	10	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21770			8,3	50	6	2	2	1	1	8,33	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21775	7798,5		6,7	60	6	2	3	1	1	10	0,67	Nodular Limestone	1		set 1: 255/75
21781			9,2	55	6	2	2	1	1	9,17	1	Nodular Limestone	1		set 1: 255/75
21786			9,2	55	6	2	2	1	1	9,17	1	Nodular Limestone	1		set 1: 255/75
21791			9,2	55	6	2	2	1	1	9,17	1	Nodular Limestone	1		set 1: 255/75
21796	2279,4		9,2	55	6	2	2	1	1	9,17	1	Nodular Limestone	1		set 1: 255/75
21801			7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21806			7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21812			7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21818	2903,1		7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21824			8,3	50	6	2	2	1	1	8,33	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21829			5,6	45	6	2	2	1	1	7,5	0,75	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21835			8,3	50	6	2	2	1	1	8,33	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21840	14412		5,6	45	6	2	2	1	1	7,5	0,75	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21846	809,8		7,5	45	6	2	2	1	1	7,5	1	Claystone	2	clay filled fracture 255/ 70	set 1: 258/70 set 2: 178/90
21851			8,3	50	6	2	2	1	1	8,33	1	Claystone	2	calcite 178/90	set 1: 258/70 set 2: 178/90
21857			7,5	45	6	2	2	1	1	7,5	1	Claystone	2	"	set 1: 258/70 set 2: 178/90
21862	13140	18	3,8	45	6	2	4	1	1	7,5	0,5	Claystone	2	"	set 1: 255/60 set 2: 177/90
21868	739,4		1,9	45	6	2	6	1	1	7,5	0,25	Nodular Limestone	1		set 1: 255/60 set 2: 177/90
21873			2,8	45	6	2	4	1	1	7,5	0,38	Nodular	1		set 1: 255/60 set 2: 177/90

												Limestone			
21878			5,0	45	6	2	3	1	1	7,5	0,67	Nodular Limestone	1	clay+water	set 1: 255/60 set 2: 178/90 set 3: 215/60
21884	10048	52	3,8	45	6	2	4	1	1	7,5	0,5	Nodular Limestone	1	Fault 258/70 and 178/90	set 1: 255/60 set 2: 178/90 set 3: 215/60
21889	1656,7		1,8	45	6	2	6	1	1	7,5	0,33	Nodular Limestone	1		set 1: 255/60 set 2: 178/90 set 3: 215/60
21895			1,0	25	6	2	6	1	1	4,17	0,25	Nodular Limestone	1		set 1: 258/50
21901	9956,7	28										Nodular Limestone	1	Fault 5m wide 078/80 with clay zone	set 1: 078/80
21902	936,4		1,9	45	6	2	6	1	1	7,5	0,25	Nodular Limestone	1		set 1: 256/70 set 2: 355/90
21908			1,9	45	6	2	6	1	1	7,5	0,25	Nodular Limestone	1		set 1: 256/70 set 2: 355/90
21917			3,1	55	6	2	6	1	1	9,17	0,33	Nodular Limestone	1		set 1: 256/70 set 2: 355/90
21919			4,6	55	6	2	4	1	1	9,17	0,5	Nodular Limestone	1		set 1: 256/70 set 2: 355/90
21923	18580	37	4,2	50	6	2	4	1	1	8,33	0,5	Nodular Limestone	1		set 1: 258/80 set 2: 350/80
21928	1338,5											Nodular Limestone	1		set 1: 258/80 set 2: 350/80
21930			5,0	60	6	2	3	1	1	10	0,5	Nodular Limestone	1	Fault 270/75	set 1: 258/80 set 2: 350/80
21936			1,7	60	9	1	4	1	1	6,67	0,25	Nodular Limestone	1	Fault 258/60	set 1: 258/80 set 2: 350/80
21941			4,6	55	6	2	3	1	1	9,17	0,5	Claystone	2		set 1: 258/90 set 2: 350/90
21944	25065		4,6	55	6	2	3	1	1	9,17	0,5	Claystone	2		set 1: 258/90 set 2: 350/90
21950	4125,4	4,5	5,0	60	6	2	3	1	1	10	0,5	Claystone	2		set 1: 258/90 set 2: 350/90
21953			5,0	60	6	2	3	1	1	10	0,5	Claystone	2		set 1: 258/90 set 2: 350/90
21958			6,7	60	6	2	3	1	1	10	0,67	Claystone	2		set 1: 258/90 set 2: 350/90
21964	24773	74,5	4,2	50	6	2	3	1	1	8,33	0,5	Claystone	2		set 1: 258/90 set 2: 350/90
21969	8687,5	2	5,0	60	6	2	3	1	1	10	0,5	Claystone	2	fold axis	set 1: 258/90 set 2: 350/90
21974			3,6	65	9	2	3	1	1	7,22	0,5	Claystone	2		set 1: 075/60
21980	930,2		2,5	60	9	2	4	1	1	6,67	0,38	Claystone	2	Fault 078/60	set 1: 075/60
21986	24192	132	5,4	65	6	2	3	1	1	10,8	0,5	Nodular Limestone	1	"	set 1: 075/60
21991	8925,6	10	2,5	60	9	2	4	1	1	6,67	0,38	Nodular Limestone	1	fold axis	set 1: 075/60

21997			3,8	60	6	2	4	1	1	10	0,38	Nodular Limestone	1	Fault layer ll	set 1: 255/75 set 2: 355/80
22004	10176	360	2,2	60	9	2	3	1	1	6,67	0,5	Nodular Limestone	1		set 1: 255/75 set 2: 355/90
22010	2125,7	3	2,6	50	9	2	3	1	1	5,56	0,67	Claystone	2		set 1: 255/75 set 2: 355/90
22015			4,4	60	9	2	3	1	1	6,67	0,67	Claystone	2	Fault + diabase 2m 255/50	set 1: 255/50 set 2: 355/80
22018	3093,8											Claystone	2		
22021	20014	169	7,2	65	6	2	3	1	1	10,8	0,67	Claystone	2		set 1: 255/50 set 2: 355/80
22026	395,8		6,7	60	6	2	3	1	1	10	0,67	Claystone	2		set 1: 255/50 set 2: 355/80
22032			10,0	60	6	2	2	1	1	10	1	Claystone	2		set 1: 255/50 set 2: 355/80
22037	14372	9	10,0	80	6	2	2	1	1	13,3	0,75	sandstone	4	Calcite coating	set 1: 255/50 set 2: 355/80
22044	370,6		10,6	85	6	2	2	1	1	14,2	0,75	sandstone	4		set 1: 255/50 set 2: 355/80
22055			6,3	75	6	2	3	1	1	12,5	0,5	Limestone	3		set 1: 255/60 set 2: 355/90
22060	12261	1	4,7	75	6	2	4	1	1	12,5	0,38	Limestone	3		set 1: 255/60 set 2: 355/90
22066	540,9		6,3	75	6	2	3	1	1	12,5	0,5	Limestone	3		set 1: 255/60 set 2: 355/90
22071			6,3	75	6	2	3	1	1	12,5	0,5	Limestone	3		set 1: 255/60 set 2: 355/90
22076	9905,7		4,2	50	6	2	3	1	1	8,33	0,5	Limestone	3		set 1: 255/60 set 2: 355/90
22082	980,6		4,2	50	6	2	3	1	1	8,33	0,5	Limestone	3		set 1: 255/60 set 2: 355/90
22087			6,3	75	6	2	3	1	1	12,5	0,5	Limestone	3		set 1: 255/70
22093	17401	13,5	4,2	50	6	2	3	1	1	8,33	0,5	Limestone	3		set 1: 255/70
22098	540		5,4	65	6	2	3	1	1	10,8	0,5	Limestone	3		set 1: 255/70 set 2: 355/90 set 3: 255/30
22104			8,1	65	4	2	3	1	1	16,3	0,5	Limestone	3		set 1: 255/70 set 2: 355/90 set 3: 255/30
22109	14224	7	5,0	60	6	2	4	1	1	10	0,5	Limestone	3	0,5cm fault 255/70	set 1: 255/70 set 2: 355/90 set 3: 255/30
22115	695,7		5,0	60	6	2	4	1	1	10	0,5	Limestone	3		set 1: 255/70 set 2: 355/90
22120	17290	2	7,2	65	6	2	3	1	1	10,8	0,67	Limestone	3		set 1: 255/70 set 2: 355/90
22128	456		5,8	70	6	2	3	1	1	11,7	0,5	Nodular Limestone	1		set 1: 255/70 set 2: 355/90 set 3: 255/30
22132			6,7	80	6	2	3	1	1	13,3	0,5	Nodular Limestone	1	Fault ll layer dip 70	set 1: 255/70 set 2: 355/90
22137	3861,9		11,3	90	6	2	2	1	1	15	0,75	Nodular Limestone	1		set 1: 255/70
22143	449,5		9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1		set 1: 255/70
22148			40,0	80	3	2	1	1	1	26,7	1,5	Nodular Limestone	1		set 1: 255/70
22154	12815		10,0	80	6	2	2	1	1	13,3	0,75	Nodular Limestone	1		set 1: 255/60 set 2: 355/90

22160	281,8		10,0	80	6	2	2	1	1	13,3	0,75	Nodular Limestone	1		set 1: 255/60 set 2: 355/90
22166			6,7	80	6	2	3	1	1	13,3	0,5	Nodular Limestone	1		set 1: 255/60 set 2: 355/90
22171			6,3	75	6	2	3	1	1	12,5	0,5	Nodular Limestone	1	clay filled fracture 255/50	set 1: 255/70
22175	7276	22,5										Nodular Limestone	1		set 1: 255/70
22181	354,7		10,0	80	6	2	2	1	1	13,3	0,75	Nodular Limestone	1		set 1: 255/70
22188			12,5	75	6	2	2	1	1	12,5	1	Nodular Limestone	1		set 1: 254/60
22191	10218	8										Nodular Limestone	1		set 1: 254/60
22195	5202,8	134	11,7	70	6	2	2	1	1	11,7	1	Nodular Limestone	1		set 1: 254/60
22197	369,8		13,3	80	6	2	2	1	1	13,3	1	Nodular Limestone	1		set 1: 254/60
22210			17,5	70	4	2	2	1	1	17,5	1	Nodular Limestone	1		set 1: 254/60 set 2: 355/90
22214			13,3	80	6	2	2	1	1	13,3	1	Nodular Limestone	1		set 1: 254/60 set 2: 355/90
22220	4845,5		12,5	75	6	2	2	1	1	12,5	1	Nodular Limestone	1		set 1: 255/60
22226	1390,6		9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1		set 1: 255/60
22231			8,8	70	6	2	2	1	1	11,7	0,75	Nodular Limestone	1		set 1: 255/60
22237			9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1		set 1: 255/80 set 2: 000/70
22242	23018	160	4,2	75	9	2	3	1	1	8,33	0,5	Nodular Limestone	1		set 1: 255/80 set 2: 000/70
22248	1565,9		5,8	70	9	2	2	1	1	7,78	0,75	Nodular Limestone	1		set 1: 255/80 set 2: 000/70
22253			5,8	70	9	2	2	1	1	7,78	0,75	Nodular Limestone	1	Fold ll tunnel trace	set 1: 255/80 set 2: 000/70
22264	39954	71	5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1		set 1: 255/70 set 2: 030/90
22270	598,4											Not mapped			
22282			12,5	75	6	2	2	1	1	12,5	1	Nodular Limestone	1		
22287	35090	63										Not mapped			

22293	459,6		5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1		set 1: 260/90 set 2: 355/70
22298			5,0	60	9	2	2	1	1	6,67	0,75	Nodular Limestone	1	clay filled fracture 260/90	set 1: 260/90 set 2: 355/70
22303			6,3	75	9	2	2	1	1	8,33	0,75	Nodular Limestone	1		set 1: 260/90 set 2: 355/70
22309	17780	28	8,8	70	6	2	2	1	1	11,7	0,75	Nodular Limestone	1		set 1: 260/90 set 2: 355/70
22314	922,6		5,8	70	6	2	3	1	1	11,7	0,5	Nodular Limestone	1	Fault 078/80 folded layering 260/30	set 1: 260/90
22320	31914	32,5	5,4	65	6	2	3	1	1	10,8	0,5	Nodular Limestone	1		set 1: 260/85
22325	570,3		6,3	75	9	2	2	1	1	8,33	0,75	Nodular Limestone	1		set 1: 078/83
22331			8,9	80	9	2	2	1	1	8,89	1	Nodular Limestone	1	diabase 002/70 clay zone follows ca 22360-22385	set 1: 078/83
22336			4,0	80	6	2	2	1	2,5	13,3	0,75	Nodular Limestone	1	" clay 078/85 reverse fault	set 1: 078/83
22342	13087		9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1	"	set 1: 260/80
22347			4,1	65	6	2	4	1	1	10,8	0,38	Nodular Limestone	1	"	set 1: 260/80
22348	215,3											Nodular Limestone	1	"	set 1: 260/80
22353			5,4	65	6	2	3	1	1	10,8	0,5	Nodular Limestone	1	" set 2 folded? Thrust fault 330/50	set 1: 255/85 set 2: 330/50
22358	19569	5	5,4	65	6	2	3	1	1	10,8	0,5	Nodular Limestone	1	"	set 1: 255/85 set 2: 330/50 set 3: 030/90
22365	351,3		3,6	65	9	2	3	1	1	7,22	0,5	Nodular Limestone	1	"	set 1: 255/85 set 2: 330/50 set 3: 030/90
22371			3,3	60	9	2	3	1	1	6,67	0,5	Nodular Limestone	1	"	set 1: 255/85 set 2: 330/50 set 3: 030/90
22377	18013	153	5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1	"	set 1: 255/85 set 2: 330/50 set 3: 030/90
22383	5169,7	8	5,0	60	9	2	2	1	1	6,67	0,75	Nodular Limestone	1	"	set 1: 255/85 set 2: 330/50 set 3: 030/90
22388			5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1	diabase stop in roof Fault 262/85	set 1: 260/70 set 2: 002/70
22394	28469	110	5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1		set 1: 260/70 set 2: 002/70
22399	3338,5	20,1	5,0	60	6	2	3	1	1	10	0,5	Nodular Limestone	1		set 1: 260/70 set 2: 002/70

22405			3,6	65	9	2	3	1	1	7,22	0,5	Nodular Limestone	1		set 1: 260/70 set 2: 002/70
22411	46553	1112	5,4	65	6	2	3	1	1	10,8	0,5	Nodular Limestone	1	Fault ll layering	set 1: 255/70 set 2: 030/45
22416	10788	105	3,3	60	9	2	3	1	1	6,67	0,5	Nodular Limestone	1		set 1: 255/70 set 2: 030/45
22422	26756		3,3	60	9	2	3	1	1	6,67	0,5	Nodular Limestone	1		set 1: 255/70 set 2: 030/45
22427	231,1		3,3	60	9	2	3	1	1	6,67	0,5	Nodular Limestone	1		set 1: 255/70 set 2: 002/90
22437	19790		3,6	65	9	2	3	1	1	7,22	0,5	Nodular Limestone	1		set 1: 255/70 set 2: 002/90
22442	419,6		2,8	50	9	2	3	1	1	5,56	0,5	Nodular Limestone	1	intrusive 270/60	set 1: 255/70 set 2: 002/90
22448			3,6	65	9	2	3	1	1	7,22	0,5	Nodular Limestone	1		set 1: 255/70 set 2: 002/90
22454	12842		3,3	60	9	2	3	1	1	6,67	0,5	Limestone	3		set 1: 255/70 set 2: 002/90
22459	661,5											Limestone	3		set 1: 255/70 set 2: 002/90
22465			8,8	70	6	2	2	1	1	11,7	0,75	Limestone	3		set 1: 255/80 set 2: 170/70
22476			8,1	65	6	2	2	1	1	10,8	0,75	Limestone	3		set 1: 255/80 set 2: 170/70
22489	7010,2		3,1	55	9	2	3	1	1	6,11	0,5	Limestone	3	Fault 5 cm 020/50 from	set 1: 255/80 set 2: 170/70 set 3: 030/40
22495			3,3	60	9	2	3	1	1	6,67	0,5	Limestone	3	"	set 1: 255/80 set 2: 170/70 set 3: 030/40
22501			2,1	50	9	2	4	1	1	5,56	0,38	Limestone	3	"	set 1: 255/80 set 2: 170/70 set 3: 030/40
22506	12592		3,1	50	6	2	4	1	1	8,33	0,38	Limestone	3		set 1: 255/80 set 2: 170/90 set 3: 030/50
22511			7,5	60	6	2	2	1	1	10	0,75	Limestone	3		set 1: 255/80 set 2: 170/90 set 3: 030/50
22516			4,2	50	9	2	2	1	1	5,56	0,75	Limestone	3		set 1: 255/70
22522	12834	42	8,1	65	6	2	2	1	1	10,8	0,75	Limestone	3		set 1: 255/70 set 2: 180/60
22528			12,5	75	6	2	2	1	1	12,5	1	Limestone	3	Trust fault ll layering	set 1: 255/70 set 2: 180/60
22533			4,2	75	9	2	3	1	1	8,33	0,5	Claystone	2	calcite swarm ll layer	set 1: 255/70 set 2: 180/60
22537	12318											Claystone	2		set 1: 255/70
22544			9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 256/70 set 2: 300/85
22549			8,8	70	6	2	2	1	1	11,7	0,75	Claystone	2		set 1: 256/70 set 2: 300/85
22555	4654,1		8,1	65	6	2	2	1	1	10,8	0,75	Claystone	2		set 1: 256/70 set 2: 300/85
22560			9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 256/70 set 2: 300/85
22565			7,5	60	6	2	2	1	1	10	0,75	Claystone	2	Fault 100/45	set 1: 256/70 set 2: 300/85
22572	8158,9	4	11,3	60	4	2	2	1	1	15	0,75	Claystone	2		set 1: 256/80
22576			6,7	60	9	2	2	1	1	6,67	1	Claystone	2	calcite ll layer	set 1: 256/70
22583			9,2	55	6	2	2	1	1	9,17	1	Claystone	2		set 1: 256/70

22587	27928	13										Claystone	2		set 1: 256/70
22593			7,5	60	6	2	2	1	1	10	0,75	Claystone	2	calcite vein 010/80 crushed rock and reverse structures 230/20	set 1: 256/70 set 2: 007/90 set 3: 230/20
22598			8,1	65	6	2	2	1	1	10,8	0,75	Nodular Limestone	1	" "	set 1: 256/70 set 2: 007/90 set 3: 230/20
22604	17190	106	7,5	60	6	2	2	1	1	10	0,75	Nodular Limestone	1	Trust fault structures	set 1: 256/70 set 2: 007/90
22609			7,2	65	6	2	3	1	1	10,8	0,67	Nodular Limestone	1	" "	set 1: 260/80 set 2: 187/80
22615			8,1	65	6	2	2	1	1	10,8	0,75	Nodular Limestone	1		set 1: 260/80 set 2: 187/80
22620	18322	11,5	12,5	75	6	2	2	1	1	12,5	1	Nodular Limestone	1		set 1: 260/80 set 2: 187/80
22625			0,3	35	9	2	4	1	5	3,89	0,38	Nodular Limestone	1		set 1: 260/30 set 2: 052/75 set 3: 158/90
22626			8,8	70	6	2	2	1	1	11,7	0,75	Limestone	3		set 1: 260/80 set 2: 187/80
22628			0,33	30	9	2	3	1	5	3,33	0,5	Nodular Limestone	1		set 1: 260/30 set 2: 052/75 set 3: 158/90
22631			9,4	75	6	2	2	1	1	12,5	0,75	Limestone	3	clayfracture 260/80 l.s	set 1: 260/80 set 2: 187/80
22638	19547	14	8,3	75	6	2	3	1	1	12,5	0,67	Limestone	3		set 1: 260/80
22644			5,0	60	6	2	3	1	1	10	0,5	Limestone	3	folded calcite ll layering	set 1: 260/80 set 2: 195/60 set 3: 139/70
22649			4,4	40	6	2	3	1	1	6,67	0,67	Limestone	3		set 1: 253/80 set 2: 187/90
22655	26292	386	8,1	65	6	2	2	1	1	10,8	0,75	Limestone	3		set 1: 253/80 set 2: 012/85
22660			5,4	65	6	2	3	1	1	10,8	0,5	Limestone	3		set 1: 253/80 set 2: 012/85
22666			5,4	65	6	2	3	1	1	10,8	0,5	Limestone	3		set 1: 253/30 set 2: 012/85
22672	21228	48	5,8	70	6	2	3	1	1	11,7	0,5	Limestone	3		set 1: 253/30 set 2: 193/80
22682			8,3	75	9	2	2	1	1	8,33	1	sandstone	4		set 1: 253/30 set 2: 193/80
22687	30397	56	3,9	70	9	2	3	1	1	7,78	0,5	sandstone	4	fold axis	set 1: 065/60 set 2: 013/65
22690												Limestone	3		
22695			5,8	70	6	2	4	1	1	11,7	0,5	Limestone	3		set 1: 065/60 set 2: 013/65
22703	40550	588										Limestone	3		set 1: 070/60 set 2: 013/65
22712			3,3	60	9	2	3	1	1	6,67	0,5	Limestone	3	intrusive 005/85 with 2-3m fault	set 1: 070/60 set 2: 005/65
22717			2,2	40	6	1	3	1	1	6,67	0,33	Limestone	3	Fault ll dike 078/85	set 1: 078/85 set 2: 005/85
22723	40098	572,7	2,8	50	9	2	3	1	1	5,56	0,5	Limestone	3	"	set 1: 078/85 set 2: 005/85 set 3: 123/30
22728			5,8	70	6	2	3	1	1	11,7	0,5	Interbedded sandstone +	4		set 1: 078/90 set 2: 005/75 set 3: 123/30

												limestone			
22734			6,3	75	6	2	3	1	1	12,5	0,5	Interbedded sandstone + limestone	4		set 1: 078/85 set 2: 005/85
22739	71077	1766,5	5,8	70	6	2	3	1	1	11,7	0,5	Interbedded sandstone + limestone	4		set 1: 078/90 set 2: 005/80
22744			8,3	75	9	2	2	1	1	8,33	1	Interbedded sandstone + limestone	4	dike 000/85	set 1: 075/80 set 2: 000/20
22749			3,9	70	9	2	3	1	1	7,78	0,5	Interbedded sandstone + limestone	4	"	set 1: 260/80 set 2: 010/80
22755	34268	357	3,1	55	9	2	3	1	1	6,11	0,5	Interbedded sandstone + limestone	4	"	set 1: 260/80 set 2: 010/80
22761			5,8	70	6	2	3	1	1	11,7	0,5	Limestone	3	"	set 1: 080/70 set 2: 000/80
22767			8,8	70	6	2	2	1	1	11,7	0,75	Limestone	3	"	set 1: 080/70 set 2: 000/80
22772	56749	1285	8,1	65	6	2	2	1	1	10,8	0,75	Limestone	3	"	set 1: 080/70 set 2: 000/80
22775			5,4	65	6	2	2	1	1	10,8	0,75	Limestone	3		set 1: 260/45 set 2: 010/80
22780			6,3	75	6	2	3	1	1	12,5	0,5	Limestone	3		set 1: 260/45 set 2: 010/80
23540			2,5	50	4	2	2	1	5	12,5	1	Nodular Limestone	1		set 1: 092/30 set 2: 120/70 set 3: 35 0/80
23548			3,8	75	4	2	2	1	5	18,8	1	Nodular Limestone	1		set 1: 092/30 set 2: 120/70 set 3: 350/80
23551			3,5	70	4	2	2	1	5	17,5	1	Limestone	3		set 1: 213/10 set 2: 330/10 set 3: 017/85 set 4: 120/70
23557			3,5	75	4	2	2	1	5	18,8	1	Limestone	3		set 1: 213/10 set 2: 330/10 set 3: 017/85 set 4: 120/70
23561	2717,9											Limestone	3		set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23561	4558,1											Limestone	3		set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23563			2,3	70	6	2	2	1	5	11,7	1	Limestone	3		set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23566			2,3	70	6	2	2	1	5	11,7	1	Limestone	3		set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23568			2,5	65	6	2	4	1	2,5	10,8	0,5	Limestone	3		set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23569	1707,6											Limestone	3		set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80

23569	3695,7		2,9	65	9	2	3	1	2,5	7,22	0,5	Limestone	3		set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23570			2,2	65	6	2	4	1	2,5	10,8	0,5	Limestone	3		set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23571			2,9	65	9	2	3	1	2,5	7,22	0,5	Limestone	3		set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23575			1,3	65	9	2	3	1	2,5	7,22	0,5	Limestone	3	Fault 112/80	set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23578			1,5	65	9	2	3	1	2,5	7,22	0,67	Limestone	3	Synform ll tunnel trace	set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23578			1,8	70	9	2	3	1	2,5	7,78	0,67	Limestone	3		set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23580	6256,4											Limestone	3		set 1: 242/30 set 2: 195/85 set 3: 112/80
23580	556,9											Limestone	3		set 1: 242/30 set 2: 195/85 set 3: 112/80
23582			1,7	75	6	2	3	1	5	12,5	0,67	Limestone	3		set 1: 102/80 set 2: 195/85 set 3: 212/55
23591			2,5	75	6	2	2	1	5	12,5	1	Limestone	3		set 1: 102/80 set 2: 195/85 set 3: 212/55
23592	7657,5		1,5	60	6	2	2	1	5	10	0,75	Limestone	3		set 1: 102/80 set 2: 195/85 set 3: 212/55
23595			1,6	65	6	2	2	1	5	10,8	0,75	Limestone	3		set 1: 102/80 set 2: 195/85 set 3: 212/55
23595			0,8	75	6	1	3	1	5	12,5	0,33	Limestone	3		set 1: 102/80 set 2: 195/85 set 3: 212/55
23598			0,8	75	6	1	3	1	5	12,5	0,33	Limestone	3	fold axis	set 1: 278/90 set 2: 195/85 set 3: 150/85
23600			2,3	70	6	2	2	1	5	11,7	1	Limestone	3		set 1: 278/90 set 2: 060/75 set 3: 140/85
23600			1,4	85	9	2	2	1	5	9,44	0,75	Limestone	3		set 1: 278/90 set 2: 060/75 set 3: 140/85
23603	4584,7		1,2	70	9	2	2	1	5	7,78	0,75	Limestone	3		set 1: 278/45 set 2: 060/75 set 3: 140/80
23603	2272,6		2,6	80	6	2	2	1	5	13,3	1	Limestone	3		set 1: 278/90 set 2: 060/75 set 3: 140/85
23605			1,6	60	6	2	2	1	5	10	0,75	Limestone	3		set 1: 260/20 set 2: 052/75 set 3: 108/80
23605			1,1	65	9	2	2	1	5	7,22	0,75	Limestone	3		set 1: 260/45 set 2: 060/75 set 3: 108/80
23611			1	60	6	2	3	1	5	10	0,5	Limestone	3		set 1: 260/20 set 2: 052/75 set 3: 108/80
23613	1528,9											Limestone	3		set 1: 260/20 set 2: 052/75 set 3: 108/80
23613	5469		0,45	40	9	2	3	1	5	4,44	0,5	Limestone	3		set 1: 260/20 set 2: 052/75 set 3: 108/80
23616			0,4	35	9	2	3	1	5	3,89	0,5	Limestone	3	calcite ll layer	set 1: 260/20 set 2: 052/75 set 3: 108/80
23622	6945,6		0,2	30	9	1	3	1	5	3,33	0,33	Limestone	3		set 1: 260/30 set 2: 052/75 set 3: 158/90
23622	8311,6											Limestone	3		set 1: 260/30 set 2: 052/75 set 3: 158/90
23631	9561,2											Nodular Limestone	1		set 1: 260/30 set 2: 052/75 set 3: 158/90
23631	2562	18										Nodular Limestone	1		set 1: 260/30 set 2: 052/75 set 3: 158/90
23634			0,26	35	9	2	3	1	5	3,89	0,5	Nodular Limestone	1		set 1: 260/30 set 2: 052/75 set 3: 158/90

23640	10672														
23640	8429,4	6													
	Total														
	87487														

Appendix B
Sub-division of Q-sections

Data compillation toward Solstad.														
Pel no.	**Water**	**Grout**	**Leakage**	**Q´-**	**RQD**	**Jn**	**Jr**	**Ja**	**Jw**	**SRF**	**RQD**	**Jr**	**Geology**	**Layering**
	Tightness	**take (L)**	**(L)**	**value**							**Jn**	**Ja**		**strike/dip**
20958	2			4,4	40	6	2,0	3	1,0	1	6,6667	0,67	Nodular Limestone	set 1:255/70 set 2:350/80
20955	2			4,4	40	6	2,0	3	1,0	1	6,6667	0,67	Nodular Limestone	set 1:255/70 set 2:350/80
20949	2	16875,5												set 1:255/70
20944	2			5,0	30	6	2,0	2	1,0	1	5	1	Nodular Limestone	set 1:255/70
20939	2			5,8	35	6	2,0	2	1,0	1	5,8333	1	Nodular Limestone	set 1:255/70
20928	2			7,5	45	6	2,0	2	1,0	1	7,5	1	Nodular Limestone	set 1:255/70 set 2: 149/30
20925	2	445	25	7,5	45	6	2,0	2	1,0	1	7,5	1	Nodular Limestone	set 1:255/70 set 2: 149/30
20918	2			8,3	50	6	2,0	2	1,0	1	8,3333	1	Nodular Limestone	set 1:254/70
20911	2	7183,2	2	5,6	50	6	2,0	3	1,0	1	8,3333	0,67	Nodular Limestone	set 1:254/70
20906	2	5248,9		6,1	55	6	2,0	3	1,0	1	9,1667	0,67	Nodular Limestone	set 1:254/70
20901	2			6,1	55	6	2,0	3	1,0	1	9,1667	0,67	Nodular Limestone	set 1:255/70 set 2:170/80
20873	2	2584,5		5,6	50	9	2,0	2	1,0	1	5,5556	1	Nodular Limestone	set 1:255/70 set 2:170/80
20867	2			4,2	50	9	1,5	2	1,0	1	5,5556	0,75	Nodular Limestone	set 1:255/70 set 2:170/80
20862	2			5,6	50	9	2,0	2	1,0	1	5,5556	1	Nodular Limestone	set 1:255/70 set 2:170/80
20856,5	2			2,8	50	9	1,5	3	1,0	1	5,5556	0,5	Nodular Limestone	set 1: 260/60
20851	2	11940,4		3,3	45	9	2,0	3	1,0	1	5	0,67	Nodular Limestone	set 1: 260/60
20845,5	2			3,7	50	9	2,0	3	1,0	1	5,5556	0,67	Nodular Limestone	set 1: 260/60
20840	2			3,7	50	9	2,0	3	1,0	1	5,5556	0,67	Nodular Limestone	set 1: 260/50 set 2: 350/90
20834,5	2			3,3	45	9	2,0	3	1,0	1	5	0,67	Nodular Limestone	set 1: 260/50 set 2: 350/90

20829,5	2	15579,5	90	5,0	45	6	2,0	3	1,0	1	7,5	0,67	Nodular Limestone	set 1: 260/50
20824	2	454,6		5,0	45	6	2,0	3	1,0	1	7,5	0,67	Nodular Limestone	set 1: 260/50
20818	2			5,0	45	6	2,0	3	1,0	1	7,5	0,67	Nodular Limestone	set 1: 260/60 set 2: 350/80
20812	2	18032	76	4,4	40	6	2,0	3	1,0	1	6,6667	0,67	Calcerous claystone	set 1: 260/60 set 2: 350/80 set 3: 118/60
20806	2	1589,2		4,1	37	6	2,0	3	1,0	1	6,1667	0,67	Calcerous claystone	set 1: 260/60 set 2: 350/80 set 3: 093/45
20801	2			4,4	40	6	2,0	3	1,0	1	6,6667	0,67	Calcerous claystone	set 1: 260/60 set 2: 350/80
20795,5	2			6,1	55	6	2,0	3	1,0	1	9,1667	0,67	Calcerous claystone	set 1: 260/60 set 2: 350/80 set 3: 118/45
20791	2	13541,1	90	6,1	55	6	2,0	3	1,0	1	9,1667	0,67	Calcerous claystone	set 1: 260/60 set 2: 350/80 set 3: 118/45
20786	2	1702,2	28	5,6	50	6	2,0	3	1,0	1	8,3333	0,67	Calcerous claystone	set 1: 260/80 set 2: 034/10
20779,5	2			6,7	60	6	2,0	3	1,0	1	10	0,67	Claystone	set 1: 260/80 set 2: 106/90
20775	2	8827,4	30	6,7	60	6	2,0	3	1,0	1	10	0,67	Nodular/Limestone	set 1: 260/80 set 2: 034/10
20769	2			8,9	80	6	2,0	3	1,0	1	13,333	0,67	Nodular Limestone	set 1: 260/80 set 2: 034/10
20768,5	2	3159,6												set 1: 260/70 set 2: 034/10
20763	2			6,7	60	6	2,0	3	1,0	1	10	0,67	Nodular/Limestone	set 1: 260/70 set 2: 034/10 set 3: 350/?
20757,5	2			6,1	55	6	2,0	3	1,0	1	9,1667	0,67	Nodular/Limestone	set 1: 260/70 set 2: 034/10
20756	2	4053,2	17											set 1: 260/70 set 2: 034/10
20753	2	406,3		5,6	50	6	2,0	3	1,0	1	8,3333	0,67	Nodular/Limestone	set 1: 260/70 set 2: 034/10
20746	2			6,7	60	6	2,0	3	1,0	1	10	0,67	Nodular/Limestone	set 1: 260/70
20740	2			10,8	65	6	2,0	2	1,0	1	10,833	1	Nodular/Limestone	set 1: 260/60 set 2: 200/? set 3: 330/90
20735	2	10287,8		9,2	55	6	2,0	2	1,0	1	9,1667	1	Nodular/Limestone	set 1: 260/60 set 2: 200/? set 3: 330/90
20729,5	2			10,0	60	6	2,0	2	1,0	1	10	1	Nodular/Limestone	set 1: 260/60 set 2: 200/? set 3: 330/90
20724	2			8,9	80	6	2,0	3	1,0	1	13,333	0,67	Calcerous claystone	set 1: 260/60 set 2: 200/? set 3: 330/90
20718,5	2			6,7	60	6	2,0	3	1,0	1	10	0,67	Nodular/Limestone	set 1:255/75 set 2:355/90
20713	2			7,8	70	6	2,0	3	1,0	1	11,667	0,67	Nodular/Limestone	set 1:255/75 set 2:355/90
20706,5	2			5,0	60	6	1,5	3	1,0	1	10	0,5	Calcerous claystone	set 1:255/75 set 2:355/90
20701	2			7,8	70	6	2,0	3	1,0	1	11,667	0,67	Calcerous claystone	set 1:255/75 set 2:355/90
20695,5	2			8,1	65	6	1,5	2	1,0	1	10,833	0,75	Calcerous claystone	set 1:255/75 set 2:355/90

20684	2			5,4	65	6	1,5	3	1,0	1	10,833	0,5	Calcerous claystone	set 1:255/75 set 2:355/90
20678	2			5,4	65	6	1,5	3	1,0	1	10,833	0,5	Claystone	set 1:255/75 set 2:355/90
20673	2			3,8	60	6	1,5	4	1,0	1	10	0,38	Claystone	set 1:255/75 set 2:355/90
20667	2	10123,6	100	5,4	65	6	1,5	3	1,0	1	10,833	0,5	Calcerous claystone	set 1:255/75 set 2:355/90
20661	2	3077,5	49,1	4,7	75	6	1,5	4	1,0	1	12,5	0,38	Calcerous claystone	set 1:255/75 set 2:355/90
20655	2			6,7	80	6	1,5	3	1,0	1	13,333	0,5	Nodular Limestone	set 1:255/75 set 2:355/90
20645,5	2	19644,4	54	0,1	10	15	1,0	6	1,0	1	0,6667	0,17	Nodular Limestone/Claystone	set 1:255/75 set 2:355/90
20640	2	1924,6	4	2,5	45	9	1,5	3	1,0	1	5	0,5	Nodular Limestone/Claystone	set 1: 255/30
20634	2			2,5	45	9	1,5	3	1,0	1	5	0,5	Nodular Limestone/Claystone	set 1: 255/30
20629	2			3,1	55	9	1,5	3	1,0	1	6,1111	0,5	Nodular Limestone/Claystone	set 1: 255/30
20623	2	23064,5	2	3,1	55	9	1,5	3	1,0	1	6,1111	0,5	Nodular Limestone/Claystone	set 1: 255/30 set 2: 355/75-90
20618	2	408		5,4	65	6	1,5	3	1,0	1	10,833	0,5	Nodular Limestone/Claystone	set 1: 255/30 set 2: 355/75-90
20612,5	2			3,1	50	6	1,5	4	1,0	1	8,3333	0,38	Nodular Limestone/Claystone	set 1: 255/30 set 2: 355/75-90
20607	2			3,1	50	6	1,5	4	1,0	1	8,3333	0,38	Nodular Limestone/Claystone	set 1: 255/30 set 2: 355/75-90
20601,5	2	12016,4	23	3,8	60	6	1,5	4	1,0	1	10	0,38	Nodular Limestone/Claystone	set 1: 255/30 set 2: 355/75-90
20595	2	1458		5,0	60	6	1,5	3	1,0	1	10	0,5	Nodular Limestone/Claystone	set 1: 255/30 set 2: 355/75-90
20590,5	2			7,1	85	6	1,5	3	1,0	1	14,167	0,5	Lime/claystone	set 1: 255/30 set 2: 355/75-90
20585	2			5,8	70	6	1,5	3	1,0	1	11,667	0,5	Lime/claystone	set 1: 255/30 set 2: 120/85
20579	2	15321,2	7	9,4	75	6	1,5	2	1,0	1	12,5	0,75	Lime/claystone	set 1: 255/30 set 2: 120/85
20573	2	585,9		5,0	60	6	1,5	3	1,0	1	10	0,5	Lime/claystone	set 1: 255/30 set 2: 120/85
20568,5	2			9,4	75	6	1,5	2	1,0	1	12,5	0,75	Lime/claystone	set 1: 255/30 set 2: 120/85
20563	2			8,8	70	6	1,5	2	1,0	1	11,667	0,75	Lime/claystone	set 1: 255/30 set 2: 120/85

20556	2	10671	50	5,0	60	6	1,5	3	1,0	1	10	0,5	Lime/claystone	set 1: 250/30 set 2: 130/90
20552	2			8,1	65	4	1,5	3	1,0	1	16,25	0,5	Lime/claystone	set 1: 250/30 set 2: 130/90
20550,5	2	765,3	55,5											set 1: 250/30 set 2: 130/90
20546,5	2			7,5	60	6	1,5	2	1,0	1	10	0,75	Lime/claystone	set 1: 250/30 set 2: 130/90
20541	2			6,9	55	6	1,5	2	1,0	1	9,1667	0,75	Lime/claystone	set 1: 250/30 set 2: 130/90
20535	2	25135,9	87	8,1	65	6	1,5	2	1,0	1	10,833	0,75	Lime/claystone	set 1: 250/30 set 2: 130/90
20529	2	4608	13	6,3	75	6	1,5	3	1,0	1	12,5	0,5	Lime/claystone	set 1: 250/30 set 2: 130/90
20524	2			6,3	75	6	1,5	3	1,0	1	12,5	0,5	Lime/claystone	set 1: 250/30 set 2: 130/90
20518	2			5,8	70	6	1,5	3	1,0	1	11,667	0,5	Lime/claystone	set 1: 250/30 set 2: 176/85
20512	2	14765,2	548	3,9	70	9	1,5	3	1,0	1	7,7778	0,5	Nodular Limestone/Claystone	set 1: 250/30 set 2: 176/85
20507	2	7831,2	16											set 1: 250/30 set 2: 176/85
20506	3			3,9	70	9	1,5	3	1,0	1	7,7778	0,5	Nodular Limestone/Claystone	set 1: 250/30 set 2: 176/85
20500,5	3			3,6	65	9	1,5	3	1,0	1	7,2222	0,5	Nodular Limestone/Claystone	set 1: 250/30 set 2: 176/85
20495	3			4,4	80	9	1,5	3	1,0	1	8,8889	0,5	Nodular Limestone/Claystone	set 1: 250/30 set 2: 176/85
20490	3	54483,3	860	4,2	75	9	1,5	3	1,0	1	8,3333	0,5	Nodular Limestone/Claystone	set 1: 250/30 set 2: 176/85
20485	3	3292,9	21	6,3	75	9	1,5	2	1,0	1	8,3333	0,75	Nodular Limestone/Claystone	set 1: 250/30 set 2: 176/85
20479	3			5,8	70	9	1,5	2	1,0	1	7,7778	0,75	Nodular/Claystone	set 1: 251/20
20473,5	3			7,5	60	6	1,5	2	1,0	1	10	0,75	Nodular Limestone	set 1: 251/20
20469	3	13863	145	5,4	65	6	1,5	2	0,7	1	10,833	0,75	Nodular Limestone	set 1: 251/10
20463	3	1636,4	0,4	5,0	60	6	1,5	3	1,0	1	10	0,5	Nodular/Claystone	set 1: 082/70 set 2: 176/90
20457	3			8,8	70	6	1,5	2	1,0	1	11,667	0,75	Nodular Limestone	set 1: 082/70 set 2: 176/90
20452	3	31990,5	11	5,6	50	6	2,0	3	1,0	1	8,3333	0,67	Nodular Limestone	set 1: 082/70 set 2: 176/90
20445	3	595,2		7,5	60	6	1,5	2	1,0	1	10	0,75	Nodular Limestone	set 1: 082/70 set 2: 176/90
20440	3			7,5	60	6	1,5	2	1,0	1	10	0,75	Lime/claystone	set 1: 082/70 set 2: 176/90

20435	3			4,2	50	6	1,5	3	1,0	1	8,3333	0,5	Lime/claystone	set 1: 083/70
20428,5	3	1133,6		4,6	55	6	1,5	3	1,0	1	9,1667	0,5	Lime/claystone	set 1: 083/70
20423	3			7,5	60	6	1,5	2	1,0	1	10	0,75	Lime/claystone	set 1: 083/70
20418	3	257		5,4	65	6	1,5	3	1,0	1	10,833	0,5	Lime/claystone	set 1: 083/70
20411	3	10940,3		5,0	60	6	1,5	3	1,0	1	10	0,5	Lime/claystone	set 1: 083/70
20405	3	666		4,6	55	6	1,5	3	1,0	1	9,1667	0,5	Lime/claystone	set 1: 083/70
20394,5	3	7077,3	5											set 1: 083/70
20389	3	633,8		3,3	60	9	1,5	3	1,0	1	6,6667	0,5	Lime/claystone	set 1: 083/70
20383,5	3			5,4	65	9	1,5	2	1,0	1	7,2222	0,75		set 1: 083/70 set 2: 122/90
20378	3			5,4	65	9	1,5	2	1,0	1	7,2222	0,75		set 1: 083/70 set 2: 122/90
20377	3	10474,7	18											
20371,5	3			3,8	60	6	1,5	4	1,0	1	10	0,38		set 1: 083/70 set 2: 122/90
20366	3	6878,8	73	4,2	50	6	1,5	3	1,0	1	8,3333	0,5		set 1: 083/70 set 2: 122/90
20360,5	3			4,6	55	6	1,5	3	1,0	1	9,1667	0,5	Nodular Limestone	set 1: 083/70 set 2: 122/90
20355	3			4,2	50	6	1,5	3	1,0	1	8,3333	0,5	Nodular Limestone	set 1: 083/70 set 2: 122/90
20349,5	3	20277,3	389	4,6	55	6	1,5	3	1,0	1	9,1667	0,5	Nodular Limestone	set 1: 083/70 set 2: 122/90
20344	3			4,6	55	6	1,5	3	1,0	1	9,1667	0,5	Nodular Limestone	set 1: 083/70 set 2: 122/90
20338,5	3	3203,4	12	4,6	55	6	1,5	3	1,0	1	9,1667	0,5	"	set 1: 083/70 set 2: 122/90
20333	3	17497,3	205	7,5	60	6	1,5	2	1,0	1	10	0,75	"	set 1: 083/70 set 2: 122/90
20327,5	3			4,6	55	6	1,5	3	1,0	1	9,1667	0,5	Nodular Limestone	set 1: 083/70 set 2: 122/90
20323	3	232,1		5,0	60	6	1,5	3	1,0	1	10	0,5	"	set 1: 083/70 set 2: 122/90
20317	3			8,8	70	6	1,5	2	1,0	1	11,667	0,75	"	set 1:255/60
20311,5	3	23991,5	10,5	5,4	65	9	1,5	2	1,0	1	7,2222	0,75	Nodular Limestone	set 1:255/60
20306,5	3	859,1		9,4	75	6	1,5	2	1,0	1	12,5	0,75	"	set 1:255/60
20301,5	3			5,4	65	9	1,5	2	1,0	1	7,2222	0,75	"	set 1:255/60 set 2: 120/90
20295	2	17533,8	5,5	5,4	65	9	1,5	2	1,0	1	7,2222	0,75	"	set 1:255/60 set 2: 120/90
20290	2	381,1		5,8	70	6	1,5	3	1,0	1	11,667	0,5	"	set 1:255/60 set 2: 120/90
20284	2			6,3	75	6	1,5	3	1,0	1	12,5	0,5	"	set 1: 254/70
20280	2	12714,9	6										"	set 1: 254/70
20274	2	369,3		5,8	70	6	1,5	3	1,0	1	11,667	0,5	"	set 1: 254/70

20267,5	2			6,3	75	6	1,5	3	1,0	1	12,5	0,5	"	set 1: 254/70
20262	2	12915,6	34	6,3	75	6	1,5	3	1,0	1	12,5	0,5	"	set 1: 254/70
20256	2	640		3,9	70	9	1,5	3	1,0	1	7,7778	0,5	"	set 1: 254/70
20250	2	16244,6	26	5,8	70	6	1,5	3	1,0	1	11,667	0,5	"	set 1: 254/70
20245	2			6,3	75	6	1,5	3	1,0	1	12,5	0,5	"	set 1: 254/70
20239	2	1459,4		5,8	70	6	1,5	3	1,0	1	11,667	0,5	"	set 1: 254/70
20234	2			9,4	75	6	1,5	2	1,0	1	12,5	0,75	"	set 1: 254/50 set 2: 172/70 set 3: 095/60
20228,5	2	9447,5		6,3	75	6	1,5	3	1,0	1	12,5	0,5	Nodular Limestone	set 1: 254/50 set 2: 172/70 set 3: 095/60
20222	2	565		10,6	85	6	1,5	2	1,0	1	14,167	0,75		set 1: 254/50 set 2: 172/70 set 3: 095/60
20217,5	2			8,8	70	6	1,5	2	1,0	1	11,667	0,75		set 1: 254/50 set 2: 172/70
20213	2	32455,6		9,4	75	6	1,5	2	1,0	1	12,5	0,75		set 1: 254/50 set 2: 172/70
20206,5	2	546,3		9,4	75	6	1,5	2	1,0	1	12,5	0,75		set 1: 252/80 set 2: 091/60
20201	2			12,5	75	6	2,0	2	1,0	1	12,5	1		set 1: 252/80 set 2: 091/60
20195,5	2	21353,1		13,3	80	6	2,0	2	1,0	1	13,333	1		set 1: 252/80 set 2: 091/60
20190	2	460		11,7	70	6	2,0	2	1,0	1	11,667	1		set 1: 258/60 set 2: 190/?
20184,5	2			9,4	75	6	1,5	2	1,0	1	12,5	0,75		set 1: 258/60 set 2: 190/?
20178	2	36436	119,5	9,4	75	6	1,5	2	1,0	1	12,5	0,75		set 1: 258/50 set 2:190/90 set 3: 008/30 set 4: 248/70
20173	2	350		4,2	75	9	1,5	3	1,0	1	8,3333	0,5	Lime/claystone	set 1: 258/50 set 2:190/90 set 3: 008/30
20168	2			4,2	75	9	1,5	3	1,0	1	8,3333	0,5	"	set 1: 258/50 set 2:190/90 set 3: 008/30
20162,5	2	21105		6,3	75	9	1,5	2	1,0	1	8,3333	0,75	"	set 1: 258/50 set 2:190/90 set 3: 008/30
20157	2			5,8	70	6	1,5	3	1,0	1	11,667	0,5	"	set 1: 254/50 set 2: 008/80
20151,5	2			5,8	70	6	1,5	3	1,0	1	11,667	0,5	"	set 1: 254/50 set 2: 350/90
20145,5	1	26942,4	167	8,8	70	6	1,5	2	1,0	1	11,667	0,75	"	set 1: 254/50 set 2: 350/90
20130	1	17039,5	145	8,8	70	6	1,5	2	1,0	1	11,667	0,75	"	set 1: 254/50 set 2: 350/90
20122,5	1			8,8	70	6	1,5	2	1,0	1	11,667	0,75	Lime/claystone	set 1: 254/50 set 2: 350/90
20117	1			9,4	75	6	1,5	2	1,0	1	12,5	0,75	Calcerous claystone	set 1: 254/50 set 2: 350/90
20112	1	14034	65,5	5,8	70	6	1,5	3	1,0	1	11,667	0,5		set 1: 254/50 set 2: 350/90
20106,5	1			9,4	75	6	1,5	2	1,0	1	12,5	0,75		set 1: 254/50 set 2: 000/80 set 3: 032/60

20100,5	1			4,4	70	6	1,5	4	1,0	1	11,667	0,38		set 1: 254/50 set 2: 350/90
20097	1	10897,9	40											set 1: 250/45
20094	1			4,4	70	6	1,5	4	1,0	1	11,667	0,38		set 1: 250/45
20088	1			9,4	75	6	1,5	2	1,0	1	12,5	0,75	Calcerous claystone	set 1: 250/45 set 2: 320/90
20081	1	24150,4	46	9,4	75	6	1,5	2	1,0	1	12,5	0,75		set 1: 250/30 set 2:329/90
20076,5	1			8,8	70	6	1,5	2	1,0	1	11,667	0,75		set 1: 250/30 set 2:329/90
20070,5	1			9,4	75	6	1,5	2	1,0	1	12,5	0,75	Claystone	set 1: 250/30 set 2:329/90
20065	1	19867,3	22											set 1: 250/30 set 2:329/90
20060	1			8,3	75	6	2,0	3	1,0	1	12,5	0,67	Claystone	set 1: 250/30 set 2:329/90
20048	1	8661,3	121,5	10,8	65	6	2,0	2	1,0	1	10,833	1	Layered Claystone	set 1: 250/20 set 2: 329/90
20043,5	1			15,0	60	4	2,0	2	1,0	1	15	1	Layered Claystone	set 1: 250/20 set 2: 329/90
20039	1			15,0	60	4	2,0	2	1,0	1	15	1	Layered Claystone	set 1: 250/20 set 2: 329/90
20032	1	9474,2	8,5	11,7	70	6	2,0	2	1,0	1	11,667	1	Layered Claystone	set 1: 250/20 set 2: 207/10
20027	1			10,0	60	6	2,0	2	1,0	1	10	1		set 1: 250/20 set 2: 150/80 set 3: 025/45 set 4: 205/45
20021,5	1			10,8	65	6	2,0	2	1,0	1	10,833	1	Calcerous claystone	set 1: 250/40 set 2: 150/80 set 3: 205/45
20017	1	16008,2	71	12,5	75	6	2,0	2	1,0	1	12,5	1	Calcerous claystone	set 1: 250/20 set 2: 070/70 set 3: 173/90 set 4: 30015
20010,5	1			11,7	70	6	2,0	2	1,0	1	11,667	1		set 1: 250/20 set 2: 070/70 set 3: 173/90 set 4: 30015
20005	1			15,0	80	4	1,5	2	1,0	1	20	0,75		set 1: 250/20 set 2: 070/70 set 3: 320/90
20000	1	30214,42	193											set 1: 250/20 set 2: 070/70 set 3: 173/90 set 4: 300/15
19994,5	1			13,3	80	6	2,0	2	1,0	1	13,333	1		set 1: 250/10 set 2: 148/80 set 3: 025/90
19989	1			13,3	80	6	2,0	2	1,0	1	13,333	1		set 1: 250/05 set 2: 148/80 set 3: 025/90
19984	1	27205	314	14,2	85	6	2,0	2	1,0	1	14,167	1		set 1: 250/05 set 2: 148/90
19978	1			9,4	75	6	1,5	2	1,0	1	12,5	0,75		set 1: 250/05 set 2: 148/90
19972	1			12,5	75	6	2,0	2	1,0	1	12,5	1	Calcerous claystone	set 1: 250/05 set 2: 148/90 set 3: 030/90
19966	1	28002,7	170,5	6,3	75	6	2,0	4	1,0	1	12,5	0,5	Calcerous claystone	set 1: 250/05 set 2: 148/90

19960	1			18,8	75	4	2,0	2	1,0	1	18,75	1	Calcerous claystone	set 1: 250/05 set 2: 148/70
19934	2	26294,4	185	8,8	70	6	1,5	2	1,0	1	11,667	0,75	Nodular Limestone/Claystone	set 1: 064/30 set 2: 100/85
19928,5	2			9,4	75	6	1,5	2	1,0	1	12,5	0,75	Nodular Limestone/Claystone	set 1: 064/30 set 2: 100/85
19923	2			8,8	70	6	1,5	2	1,0	1	11,667	0,75	Nodular Limestone/Claystone	set 1: 064/30 set 2: 100/85
19917	2	19119,6	18	9,4	75	6	1,5	2	1,0	1	12,5	0,75	Nodular Limestone/Claystone	set 1: 075/30 set 2: 359/85
19911	2			14,1	75	4	1,5	2	1,0	1	18,75	0,75	Nodular Limestone/Claystone	set 1: 075/30 set 2: 359/85
19906,5	2			9,4	75	6	1,5	2	1,0	1	12,5	0,75	Nodular Limestone/Claystone	set 1: 075/30 set 2: 359/85
19901	2	31965,6	15	9,4	75	6	1,5	2	1,0	1	12,5	0,75	Nodular Limestone/Claystone	set 1: 075/45 set 2: 359/85
19895	2			9,4	75	6	1,5	2	1,0	1	12,5	0,75	Nodular Limestone/Claystone	set 1: 075/45 set 2: 359/85
19890	2			9,4	75	6	1,5	2	1,0	1	12,5	0,75	Nodular Limestone/Claystone	set 1: 075/45 set 2: 359/85
19885	2	25097,7	24	5,4	65	6	1,5	3	1,0	1	10,833	0,5	Nodular Limestone/Claystone	set 1: 075/45 set 2: 179/85
19874	2			4,4	80	6	1,0	3	1,0	1	13,333	0,33	Nodular Limestone/Claystone	set 1: 070/45 set 2: 163/70 set 3: 215/85
19867	2	9016,2		5,8	70	6	1,5	3	1,0	1	11,667	0,5		set 1: 075/60 set 2: 163/70 set 3: 215/85
		Totalt												
		1012263												

Data compilation toward Hønsveien.

Pel no.	Water tightness	Grout take (L)	Leakage (L)	Q´-value	RQD	Jn	Jr	Ja	Jw	SRF	Geology		Layering strike/dip
20970	2	1267,1		5,0	45	6	2	3	1	1	Nodular Limestone		set 1: 248/80 set 2: 350/80
20977	2			5,0	30	6	2	2	1	1	Nodular Limestone		set 1: 248/80 set 2: 350/80
20982	2			6,7	40	6	2	2	1	1	Nodular Limestone		set 1: 248/80 set 2: 350/80
20987	2			6,7	40	6	2	2	1	1	Nodular Limestone		set 1: 248/80 set 2: 350/80
20993	2	1045,8		7,5	45	6	2	2	1	1	Nodular Limestone		set 1: 248/80 set 2: 350/80
20998	2			10,0	60	6	2	2	1	1	Nodular Limestone		set 1: 258/70 set 2: 178/90
21764	2			10,0	60	6	2	2	1	1	Nodular Limestone		set 1: 258/70 set 2: 178/90
21770	2			8,3	50	6	2	2	1	1	Nodular Limestone		set 1: 258/70 set 2: 178/90
21775	2	7798,5		6,7	60	6	2	3	1	1	Nodular Limestone		set 1: 255/75
21781	2			9,2	55	6	2	2	1	1	Nodular Limestone		set 1: 255/75
21786	2			9,2	55	6	2	2	1	1	Nodular Limestone		set 1: 255/75
21791	2			9,2	55	6	2	2	1	1	Nodular Limestone		set 1: 255/75
21795,5	2	2279,4		9,2	55	6	2	2	1	1	Nodular Limestone		set 1: 255/75
21801	2			7,5	45	6	2	2	1	1	Nodular Limestone		set 1: 258/70 set 2: 178/90
21806	2			7,5	45	6	2	2	1	1	Nodular Limestone		set 1: 258/70 set 2: 178/90
21812	2			7,5	45	6	2	2	1	1	Nodular Limestone		set 1: 258/70 set 2: 178/90
21818	2	2903,1		7,5	45	6	2	2	1	1	Nodular Limestone		set 1: 258/70 set 2: 178/90
21823,5	2			8,3	50	6	2	2	1	1	Nodular Limestone		set 1: 258/70 set 2: 178/90
21829	2			5,6	45	6	2	2	1	1	Nodular Limestone		set 1: 258/70 set 2: 178/90
21834,5	2			8,3	50	6	2	2	1	1	Nodular Limestone		set 1: 258/70 set 2: 178/90
21840	2	14412		5,6	45	6	2	2	1	1	Nodular Limestone		set 1: 258/70 set 2: 178/90
21845,5	2	809,8		7,5	45	6	2	2	1	1	claystone		set 1: 258/70 set 2: 178/90
21851	2			8,3	50	6	2	2	1	1	claystone		set 1: 258/70 set 2: 178/90
21857	2			7,5	45	6	2	2	1	1	claystone		set 1: 258/70 set 2: 178/90

21862	2	13140	18	3,8	45	6	2	4	1	1	claystone		set 1: 255/60 set 2: 177/90
21867,5	2	739,4		1,9	45	6	2	6	1	1	Nodular Limestone		set 1: 255/60 set 2: 177/90
21873	2			2,8	45	6	2	4	1	1	Nodular Limestone		set 1: 255/60 set 2: 177/90

21889	2	1656,7		1,8	45	6	2	6	0,7	1	clayst./diabase		set 1: 255/60 set 2: 178/90 set 3: 215/60
21895	2			1,0	25	6	2	6	1	1	clayst./diabase		set 1: 258/50
21901	2	9956,7	28	1,9	45	6	2	6	1	1	clayst./diabase		set 1: 078/80
21902	2	936,4		1,9	45	6	2	6	1	1	clayst./diabase		set 1: 256/70 set 2: 355/90
21907,5	2			1,9	45	6	2	6	1	1	Claystone		set 1: 256/70 set 2: 355/90

21917	2			3,1	55	6	2	6	1	1	Claystone		set 1: 256/70 set 2: 355/90
21919	2			4,6	55	6	2	4	1	1	Nodular Limestone		set 1: 256/70 set 2: 355/90
21922,5	2	18580	37	4,6	55	6	2	4	1	1			set 1: 258/80 set 2: 350/80
21928	2	1338,5		4,2	50	6	2	4	1	1	Nodular Limestone		set 1: 258/80 set 2: 350/80
21930	2			5,0	60	6	2	3	1	1	Claystone		set 1: 258/80 set 2: 350/80

21941	2			4,6	55	6	2	3	1	1	Claystone		set 1: 258/90 set 2: 350/90
21944	2	25065		4,6	55	6	2	3	1	1	Claystone		set 1: 258/90 set 2: 350/90
21949,5	2	4125,4	4,5	5,0	60	6	2	3	1	1			set 1: 258/90 set 2: 350/90
21952,5	2			5,0	60	6	2	3	1	1	Claystone		set 1: 258/90 set 2: 350/90
21958	2			6,7	60	6	2	3	1	1	Claystone		set 1: 258/90 set 2: 350/90
21964	2	24773	74,5	4,2	50	6	2	3	1	1	Claystone		set 1: 258/90 set 2: 350/90
21968,5	2	8687,5	2	5,0	60	6	2	3	1	1	Claystone		set 1: 258/90 set 2: 350/90
21974	2			3,6	65	9	2	3	1	1	Claystone		set 1: 075/60

21991	2	8925,6	10	2,5	60	9	2	4	1	1	Nodular Limestone		set 1: 075/60
21997	2			3,8	60	6	2	4	1	1	Nodular Limestone		set 1: 255/75 set 2: 355/80

22003,5	2	10176	360	2,2	60	9	2	3	0,7	1	Nodular Limestone		set 1: 255/75 set 2: 355/90
22010	2	2125,7	3	2,6	50	9	2	3	0,7	1	Nodular Limestone		set 1: 255/75 set 2: 355/90
22021	2	20014	169	7,2	65	6	2	3	1	1	Nodular Limestone		set 1: 255/50 set 2: 355/80
22026	2	395,8		6,7	60	6	2	3	1	1	Nodular Limestone		set 1: 255/50 set 2: 355/80
22032	2			10,0	60	6	2	2	1	1	Nodular Limestone		set 1: 255/50 set 2: 355/80
22037	2	14372	9	10,0	80	6	2	2	1	1	sandstone		set 1: 255/50 set 2: 355/80
22043,5	2	370,6		10,6	85	6	2	2	1	1	sandstone		set 1: 255/50 set 2: 355/80
22054,5	2			6,3	75	6	2	3	1	1	Claystone		set 1: 255/60 set 2: 355/90
22060	2	12261	1	4,7	75	6	2	4	1	1	Claystone		set 1: 255/60 set 2: 355/90
22065,5	2	540,9		6,3	75	6	2	3	1	1	Claystone		set 1: 255/60 set 2: 355/90
22071	2			6,3	75	6	2	3	1	1	Claystone		set 1: 255/60 set 2: 355/90
22076	2	9905,7		4,2	50	6	2	3	1	1	Nodular Limestone		set 1: 255/60 set 2: 355/90
22081,5	2	980,6		4,2	50	6	2	3	1	1	Nodular Limestone		set 1: 255/60 set 2: 355/90
22087	2			6,3	75	6	2	3	1	1	Nodular Limestone		set 1: 255/70
22092,5	2	17401	13,5	4,2	50	6	2	3	1	1	Claystone		set 1: 255/70
22098	2	540		5,4	65	6	2	3	1	1	Claystone		set 1: 255/70 set 2: 355/90 set 3: 255/30
22109	2	14224	7	5,0	60	6	2	4	1	1	Lime/claystone		set 1: 255/70 set 2: 355/90 set 3: 255/30
22115	2	695,7		5,0	60	6	2	4	1	1	Lime/claystone		set 1: 255/70 set 2: 355/90
22120	2	17290	2	7,2	65	6	2	3	1	1	Lime/claystone		set 1: 255/70 set 2: 355/90
22128	2	456		5,8	70	6	2	3	1	1	Nodular Limestone		set 1: 255/70 set 2: 355/90 set 3: 255/30
22132	2			6,7	80	6	2	3	1	1	Nodular Limestone		set 1: 255/70 set 2: 355/90

22137	2	3861,9		11,3	90	6	2	2	1	1	Nodular Limestone		set 1: 255/70
22143	2	449,5		9,4	75	6	2	2	1	1	Nodular Limestone		set 1: 255/70
22154	2	12815		10,0	80	6	2	2	1	1	Nodular Limestone		set 1: 255/60 set 2: 355/90
22160	2	281,8		10,0	80	6	2	2	1	1	Nodular Limestone		set 1: 255/60 set 2: 355/90
22165,5	2			6,7	80	6	2	3	1	1	Nodular Limestone		set 1: 255/60 set 2: 355/90
22171	2			6,3	75	6	2	3	1	1	Nodular Limestone		set 1: 255/70
22187,5	2			12,5	75	6	2	2	1	1			set 1: 254/60 set 2: 355/90
22191	2	10218	8										set 1: 254/60 set 2: 355/90
22195	2	5202,8	134	11,7	70	6	2	2	1	1			set 1: 254/60 set 2: 355/90
22196,5	2	369,8		13,3	80	6	2	2	1	1	Lime/claystone		set 1: 254/60 set 2: 355/90
22209,5	2			17,5	70	4	2	2	1	1	Lime/claystone		set 1: 254/60 set 2: 355/90
22214	2			13,3	80	6	2	2	1	1			set 1: 254/60 set 2: 355/90
22220	2	4845,5		12,5	75	6	2	2	1	1			set 1: 255/60
22225,5	2	1390,6		9,4	75	6	2	2	1	1	Nodular		set 1: 255/60
22231	2			8,8	70	6	2	2	1	1	Lime/claystone		set 1: 255/60
22236,5	2			9,4	75	6	2	2	1	1			set 1: 255/80 set 2: 000/70
22242	2	23018	160	4,2	75	9	2	3	1	1	Lime/claystone		set 1: 255/80 set 2: 000/70
22247,5	2	1565,9		5,8	70	9	2	2	1	1	Nodular Limestone		set 1: 255/80 set 2: 000/70
22253	2			5,8	70	9	2	2	1	1			set 1: 255/80 set 2: 000/70
22264	2	39954	71	5,4	65	9	2	2	1	1			set 1: 255/70 set 2: 030/90

22292,5	2	459,6		5,4	65	9	2	2	1	1			Not mapped
22297,5	2			5,0	60	9	2	2	1	1			set 1: 260/90 set 2: 355/70
22303	2			6,3	75	9	2	2	1	1			set 1: 260/90 set 2: 355/70
22309	2	17780	28	8,8	70	6	2	2	1	1	Nodular Limestone		set 1: 260/90 set 2: 355/70
22314	2	922,6		5,8	70	6	2	3	1	1			set 1: 260/90
22320	2	31914	32,5	5,4	65	6	2	3	1	1	Nodular Limestone		set 1: 260/85
22325	2	570,3		6,3	75	9	2	2	1	1	Nodular Limestone		set 1: 078/83
22330,5	2			8,9	80	9	2	2	1	1			set 1: 078/83
22336	2			4,0	80	6	2	2	1	2,5			set 1: 078/83
22342	2	13087		9,4	75	6	2	2	1	1			set 1: 260/80
22348	2	215,3		4,1	65	6	2	4	1	1			set 1: 260/80
22352,5	2			5,4	65	6	2	3	1	1			set 1: 255/85 set 2: 330/50
22358	2	19569	5	5,4	65	6	2	3	1	1			set 1: 255/85 set 2: 330/50 set 3: 030/?
22365	2	351,3		3,6	65	9	2	3	1	1			set 1: 255/85 set 2: 330/50 set 3: 030/?
22371	2			3,3	60	9	2	3	1	1			set 1: 255/85 set 2: 330/50 set 3: 030/?
22377	2	18013	153	5,4	65	9	2	2	1	1			set 1: 255/85 set 2: 330/50 set 3: 030/?
22382,5	2	5169,7	8	5,0	60	9	2	2	1	1			set 1: 255/85 set 2: 330/50 set 3: 030/?
22388	2			5,4	65	9	2	2	1	1			set 1: 260/70 set 2: 002/70
22394	2	28469	110	5,4	65	9	2	2	1	1	Nodular Limestone		set 1: 260/70 set 2: 002/70
22399	2	3338,5	20,1	5,0	60	6	2	3	1	1			set 1: 260/70 set 2: 002/70
22405	2			3,6	65	9	2	3	1	1			set 1: 260/70 set 2: 002/70
22411	2	46553	1112	5,4	65	6	2	3	1	1			set 1: 255/70 set 2: 030/?
22416	2	10788	105	3,3	60	9	2	3	1	1			set 1: 255/70 set 2: 030/?
22422	2	26756		3,3	60	9	2	3	1	1			set 1: 255/70 set 2: 030/?

22427	2	231,1		3,3	60	9	2	3	1	1			set 1: 255/70 set 2: 002/90
22437	2	19790		3,6	65	9	2	3	1	1			set 1: 255/70 set 2: 002/90
22442	2	419,6		2,8	50	9	2	3	1	1			set 1: 255/70 set 2: 002/90
22448	2			3,6	65	9	2	3	1	1			set 1: 255/70 set 2: 002/90
22454	2	12842		3,3	60	9	2	3	1	1			set 1: 255/70 set 2: 002/90

22459	2	661,5											set 1: 255/70 set 2: 002/90
22465	2			8,8	70	6	2	2	1	1			set 1: 255/80 set 2: 170/70
22476	2			8,1	65	6	2	2	1	1			set 1: 255/80 set 2: 170/70

22489	2	7010,2		3,1	55	9	2	3	1	1	Lime/claystone		set 1: 255/80 set 2: 170/70 set 3: 030/40
22495				3,3	60	9	2	3	1	1			set 1: 255/80 set 2: 170/70 set 3: 030/40
22500,5				2,1	50	9	2	4	1	1	clay in fracture		set 1: 255/80 set 2: 170/70 set 3: 030/40
22506	2	12592		3,1	50	6	2	4	1	1			set 1: 255/80 set 2: 170/90 set 3: 030/50

22544				9,4	75	6	2	2	1	1	claystone		set 1: 256/70 set 2: 030/?
22548,5				8,8	70	6	2	2	1	1			set 1: 256/70 set 2: 030/?
22555	2	4654,1		8,1	65	6	2	2	1	1			set 1: 256/70 set 2: 030/?
22559,5				9,4	75	6	2	2	1	1			set 1: 256/70 set 2: 030/?
22565				7,5	60	6	2	2	1	1			set 1: 256/70 set 2: 030/?
22572	2	8158,9	4	11,3	60	4	2	2	1	1	Claystone		set 1: 256/80
22576				6,7	60	9	2	2	1	1			set 1: 256/70
22583				9,2	55	6	2	2	1	1			set 1: 256/70

22593				7,5	60	6	2	2	1	1			set 1: 256/70 set 2: 007/90 set 3:

													230/20
22598				8,1	65	6	2	2	1	1	Claystone/Nodular Limestone		set 1: 256/70 set 2: 007/90 set 3: 230/20
22604	2	17190	106	7,5	60	6	2	2	1	1	Claystone/Nodular Limestone		set 1: 256/70 set 2: 007/90
22609				7,2	65	6	2	3	1	1			set 1: 260/80 set 2: 187/80
22614,5				8,1	65	6	2	2	1	1	Claystone/Nodular Limestone		set 1: 260/80 set 2: 187/80
22625,5				8,8	70	6	2	2	1	1	claystone		set 1: 260/80 set 2: 187/80
22631				9,4	75	6	2	2	1	1			set 1: 260/80 set 2: 187/80
22638	2	19547	14	8,3	75	6	2	3	1	1			set 1: 260/80
22644				5,0	60	6	2	3	1	1			set 1: 260/80 set 2: 195/60 set 3: 139/70
22649				4,4	40	6	2	3	1	1			set 1: 253/80 set 2: 187/90
22655		26292	386	8,1	65	6	2	2	1	1			set 1: 253/80 set 2: 012/85
22660				5,4	65	6	2	3	1	1			set 1: 253/80 set 2: 012/85
22666				5,4	65	6	2	3	1	1	claystone		set 1: 253/30 set 2: 012/85
22671,5	2	21228	48	5,8	70	6	2	3	1	1	claystone		set 1: 253/30 set 2: 193/80
22711,5	2			3,3	60	9	2	3	1	1	claystone		set 1: 070/60 set 2: 005/65
22717	2			2,2	40	6	1	3	1	1	claystone		set 1: 078/85 set 2: 005/85
22722,5	2	40098	572,7	2,8	50	9	2	3	1	1			set 1: 078/85 set 2: 005/85 set 3: 123/30
22728	2			5,8	70	6	2	3	1	1	sandstone + lime/clay stone		set 1: 078/90 set 2: 005/75 set 3: 123/30
22733,5	2			6,3	75	6	2	3	1	1	sandstone + lime/clay stone		set 1: 078/85 set 2: 005/85

22738,5	2	71077	1766,5	5,8	70	6	2	3	1	1	sandstone + lime/clay stone		set 1: 078/90 set 2: 005/80
22743,5	2			8,3	75	9	2	2	1	1	sandstone + lime/clay stone		set 1: 075/80 set 2: 000/20
22749	2			3,9	70	9	2	3	1	1	sandstone + lime/clay stone		set 1: 260/80 set 2: 010/80
22755	2	34268	357	3,1	55	9	2	3	1	1	sandstone + lime/clay stone		set 1: 260/80 set 2: 010/80
22761	2			5,8	70	6	2	3	1	1	claystone		set 1: 080/70 set 2: 000/80
22766,5	2			8,8	70	6	2	2	1	1	claystone		set 1: 080/70 set 2: 000/80
22772	2	56749	1285	8,1	65	6	2	2	1	1	claystone		set 1: 080/70 set 2: 000/80
22775	2			5,4	65	6	2	2	0,7	1	claystone		set 1: 260/45 set 2: 010/80
22780	2			6,3	75	6	2	3	1	1	claystone		set 1: 260/45 set 2: 010/80

Pel no.	Water tightness	Grout take (L)	Leakage (L)	Q´-value	RQD	Jn	Jr	Ja	Jw	SRF	Geology	Layering strike/dip
23640	2	10672,1										
23640	2	8429,4	6									
23634				0,26	35	9	2	3	1	5	Nodular Limestone	set 1: 260/30 set 2: 052/75 set 3: 158/90
23631	2	9561,2									Nodular Limestone	set 1: 260/30 set 2: 052/75 set 3: 158/90
23631	2	2562	18								Nodular Limestone	set 1: 260/30 set 2: 052/75 set 3: 158/90
22628				0,33	30	9	2	3	1	5	Nodular Limestone	set 1: 260/30 set 2: 052/75 set 3: 158/90
22625	hs			0,3	35	9	2	4	1	5	Nodular Limestone	set 1: 260/30 set 2: 052/75 set 3: 158/90
23622	2	6945,6		0,2	30	9	1	3	1	5	Limestone	set 1: 260/30 set 2: 052/75 set 3: 158/90
23622	2	8311,6									Limestone	set 1: 260/30 set 2: 052/75 set 3: 158/90
23616	hs			0,4	35	9	2	3	1	5	Limestone	set 1: 260/20 set 2: 052/75 set 3: 108/80
23613	2	1528,9									Limestone	set 1: 260/20 set 2: 052/75 set 3: 108/80
23613	hs	5469		0,45	40	9	2	3	1	5	Limestone	set 1: 260/20 set 2: 052/75 set 3: 108/80
23611				1	60	6	2	3	1	5	Limestone	set 1: 260/20 set 2: 052/75 set 3: 108/80
23605	hs			1,6	60	6	2	2	1	5	Limestone	set 1: 260/20 set 2: 052/75 set 3: 108/80
23605				1,1	65	9	2	2	1	5	Limestone	set 1: 260/45 set 2: 060/75 set 3: 108/80
23603	hs	4584,7		1,2	70	9	2	2	1	5	Limestone	set 1: 278/45 set 2: 060/75 set 3: 140/80
23603	2	2272,6		2,6	80	6	2	2	1	5	Limestone	set 1: 278/90 set 2: 060/75 set 3: 140/85
23600	hs			2,3	70	6	2	2	1	5	Limestone	set 1: 278/90 set 2: 060/75 set 3: 140/85
23600				1,4	85	9	2	2	1	5	Limestone	set 1: 278/90 set 2: 060/75 set 3: 140/85
23598	vs			0,8	75	6	1	3	1	5	Limestone	set 1: 278/90 set 2: 195/85 set 3: 150/85
23595	hs			1,6	65	6	2	2	1	5	Limestone	set 1: 102/80 set 2: 195/85 set 3: 212/55
23595				0,8	75	6	1	3	1	5	Limestone	set 1: 102/80 set 2: 195/85 set 3: 212/55
23592	hs	7657,5		1,5	60	6	2	2	1	5	Limestone	set 1: 102/80 set 2: 195/85 set 3: 212/55
23591				2,5	75	6	2	2	1	5	Limestone	set 1: 102/80 set 2: 195/85 set 3: 212/55
23582				1,7	75	6	2	3	1	5	Limestone	set 1: 102/80 set 2: 195/85 set 3: 212/55
23580		6256,4									Limestone	set 1: 242/30 set 2: 195/85 set 3: 112/80
23580		556,9									Limestone	set 1: 242/30 set 2: 195/85 set 3: 112/80
23578	hs			1,5	65	9	2	3	1	2,5	Limestone	set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23578	vs			1,8	70	9	2	3	1	2,5	Limestone	set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4:

												120/80
23575	hs			1,3	65	9	2	3	1	2,5	Limestone	set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80

23571	hs			2,9	65	9	2	3	1	2,5	Limestone	set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23569		1707,6									Limestone	set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23569	hs	3695,7		2,9	65	9	2	3	1	2,5	Limestone	set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23570	vs			2,2	65	6	2	4	1	2,5	Limestone	set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23568	vs			2,5	65	6	2	4	1	2,5	Limestone	set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23566	vs			2,3	70	6	2	2	1	5	Limestone	set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23563	vs			2,3	70	6	2	2	1	5	Limestone	set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23561		2717,9									Limestone	set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23561		4558,1									Limestone	set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23557				3,5	75	4	2	2	1	5	Limestone	set 1: 213/10 set 2: 330/10 set 3: 017/85 set 4: 120/70
23551				3,5	70	4	2	2	1	5	Limestone	set 1: 213/10 set 2: 330/10 set 3: 017/85 set 4: 120/70
23548				3,8	75	4	2	2	1	5	Nodular Limestone	set 1: 092/30 set 2: 120/70 set 3: 350/80
23540				2,5	50	4	2	2	1	5	Nodular Limestone	set 1: 092/30 set 2: 120/70 set 3: 35/80

Appendix C

Graphic presentation of correlation data

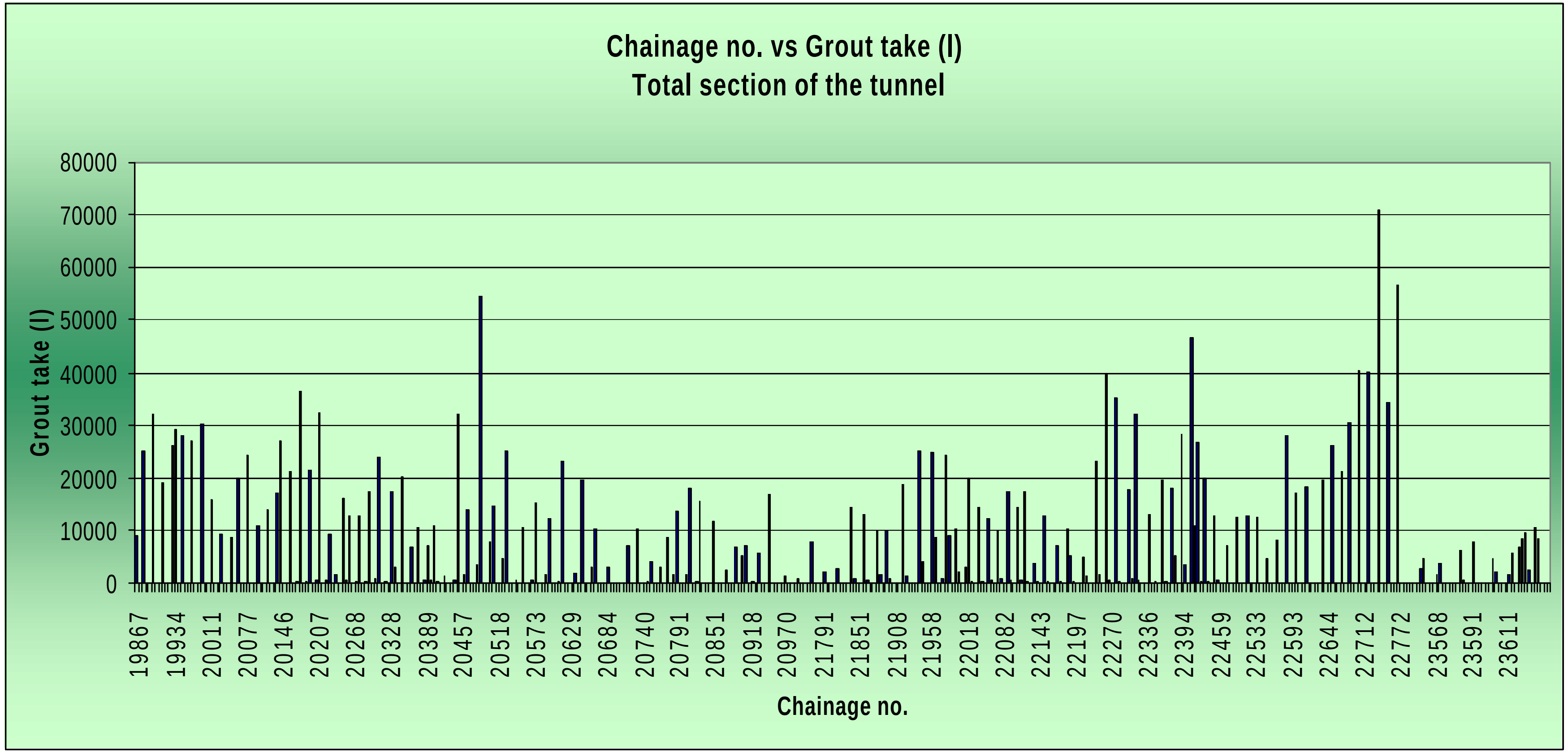


Figure C.1 Presentation of the variation in Q-value compared to chainage number along the tunnel.

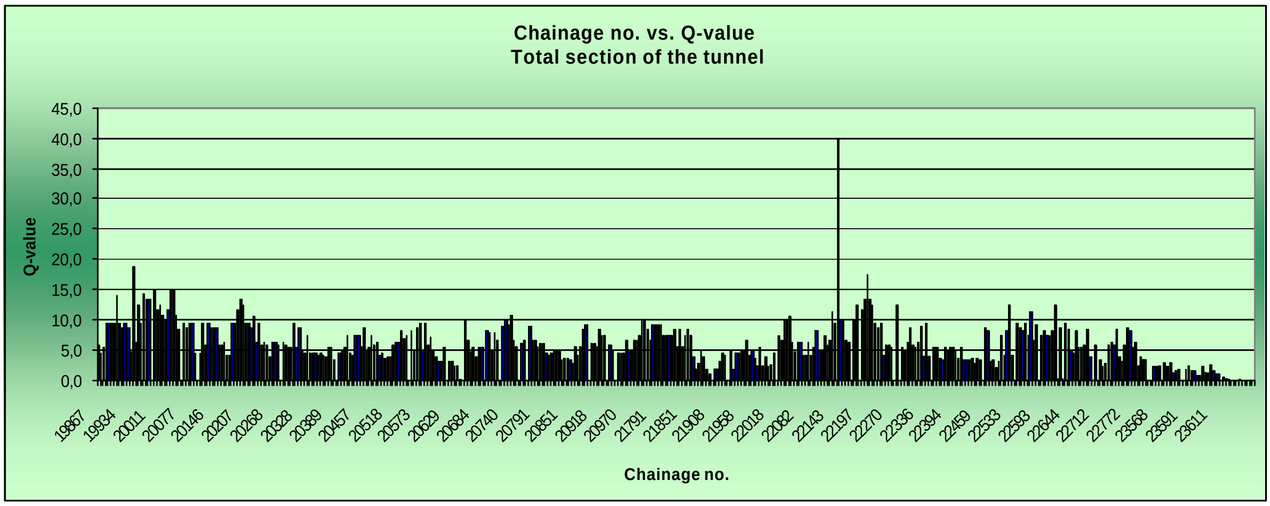


Figure C.2 Representation of the variation in grout take compared to chainage number along the tunnel.

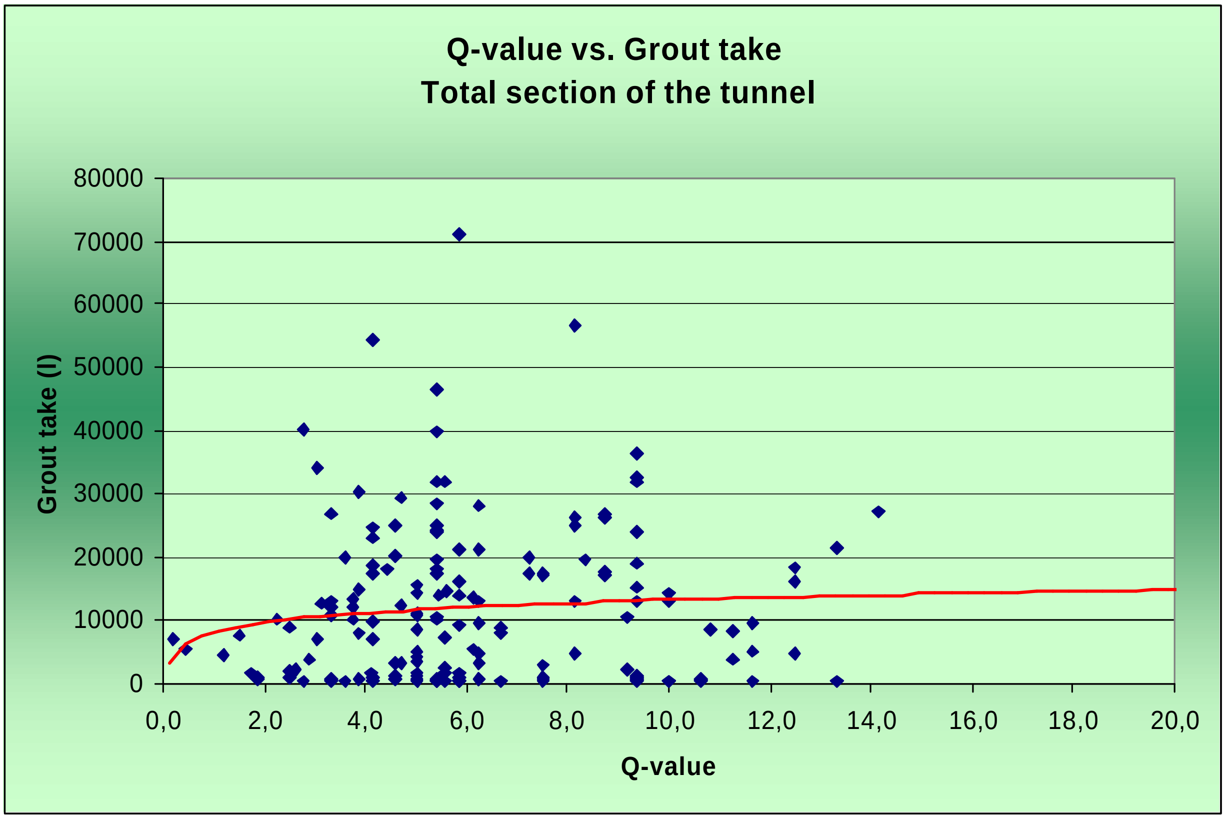


Figure C.3 Presentation of how the Q-value varies with grout take for the total section of the tunnel.

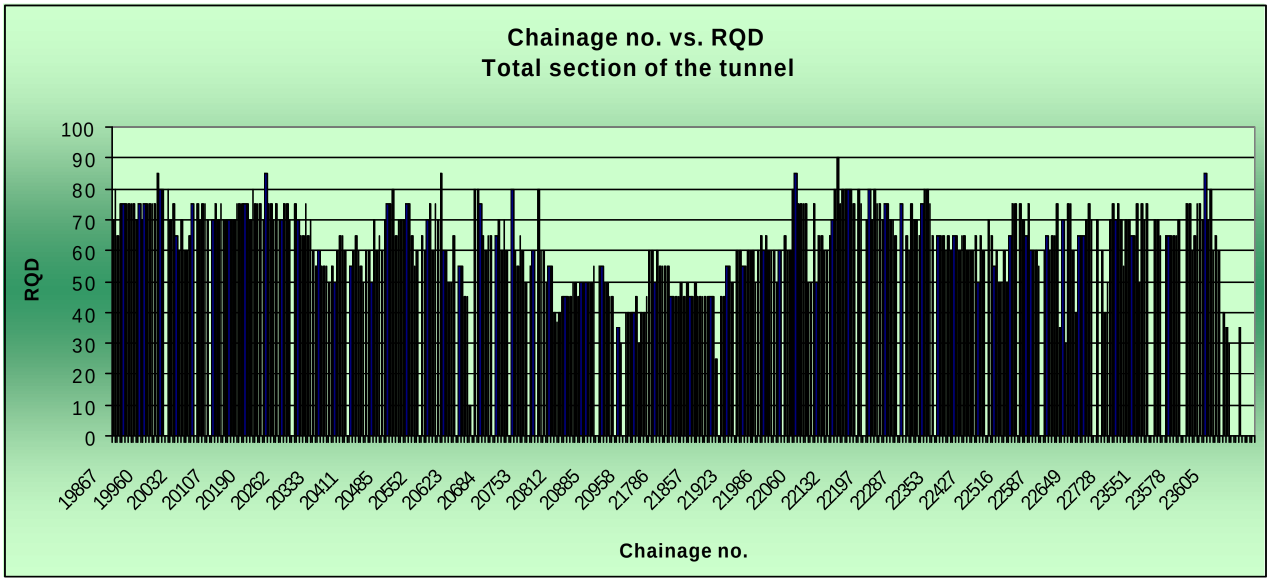


Figure C.4 Presentation of the variation in RQD-value (rock quality designation) compared to chainage number along the tunnel.

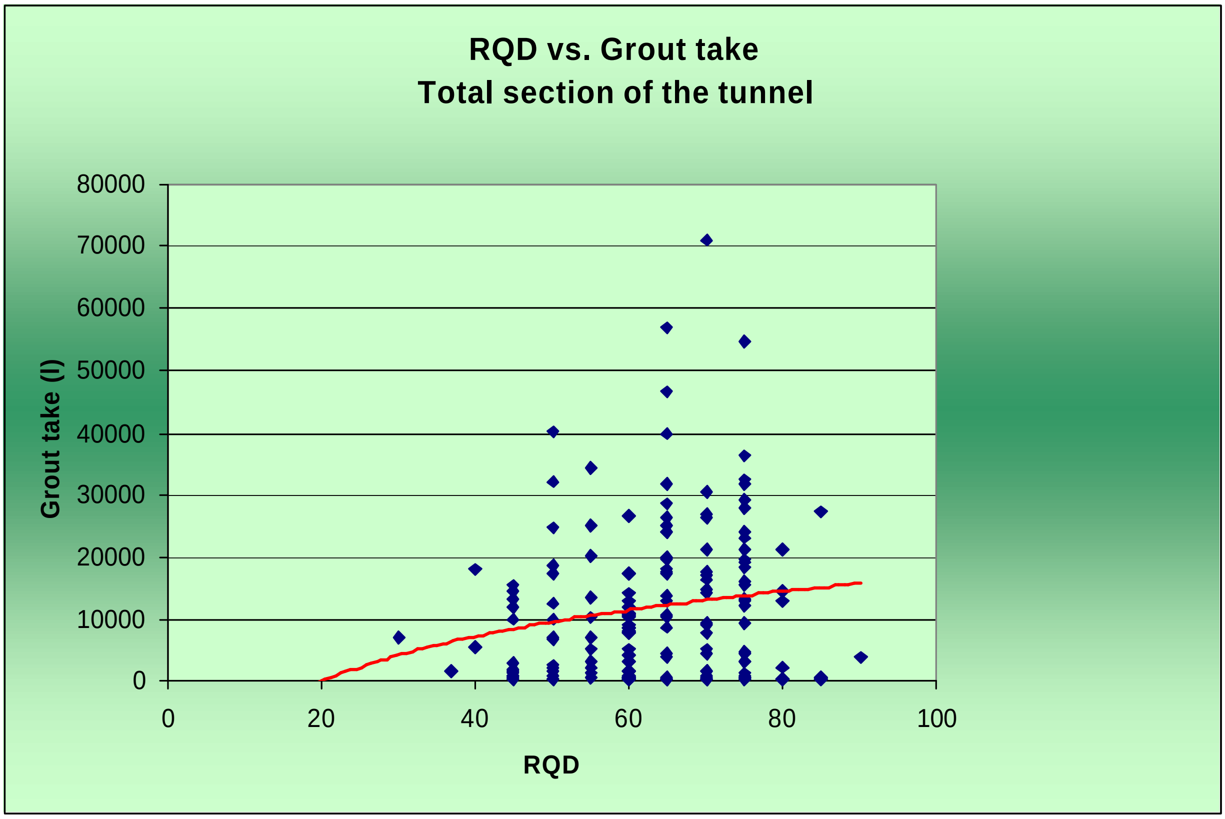


Figure 6.5 Presentation of how the RQD-value varies with grout take for the total section of the tunnel.

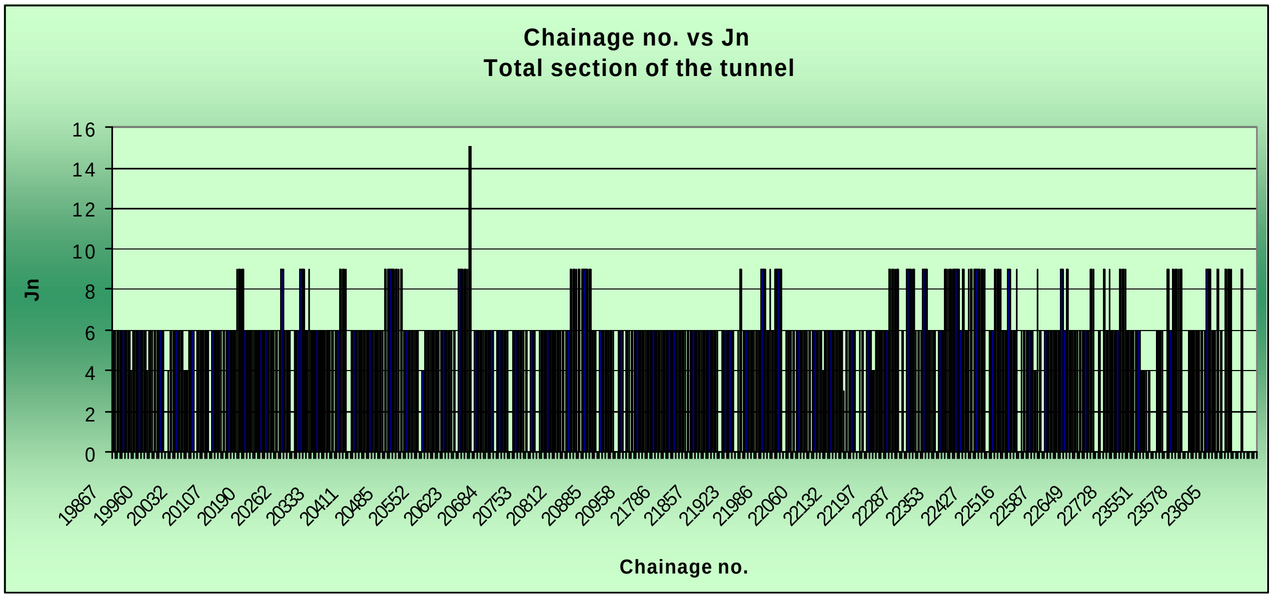


Figure C.6 Presentation of the variation in Jn-value (joint set number) compared to chainage number along the tunnel.

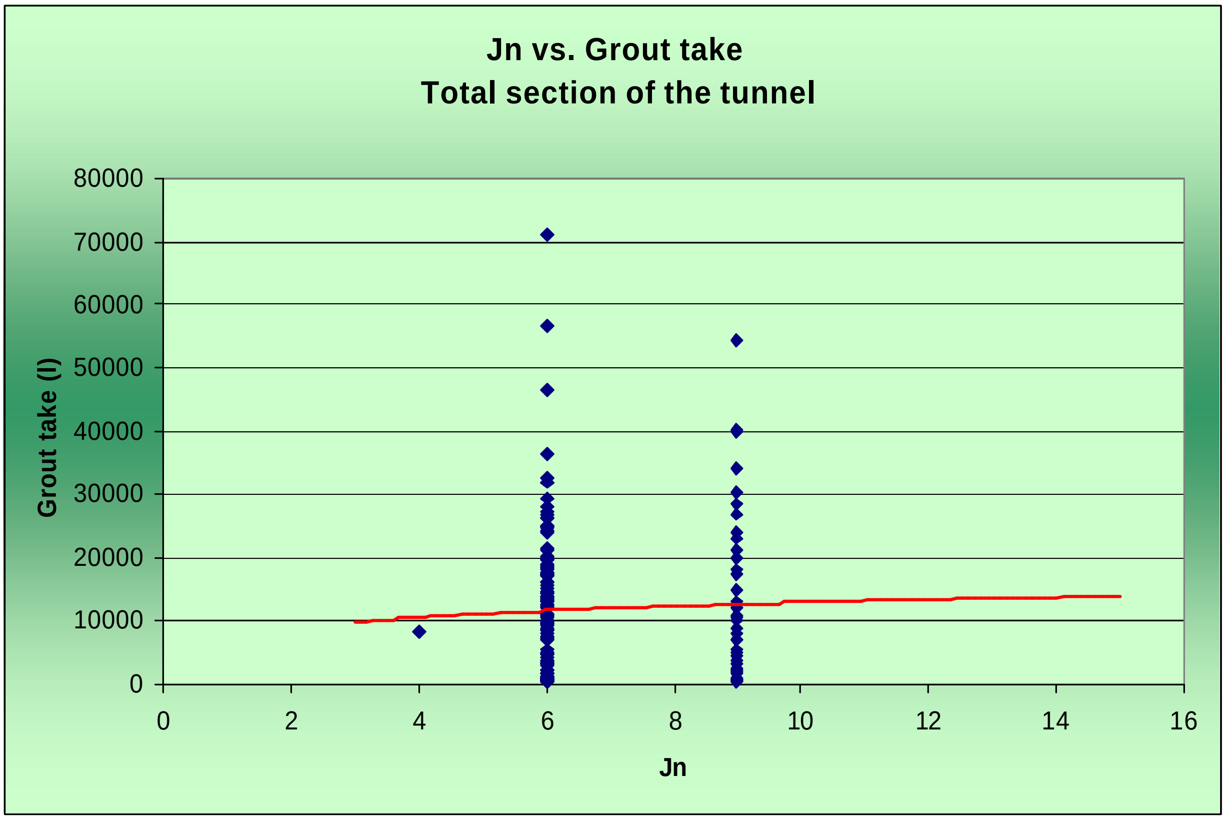


Figure C.7 Presentation of how the Jn-value varies with grout take for the total section of the tunnel.

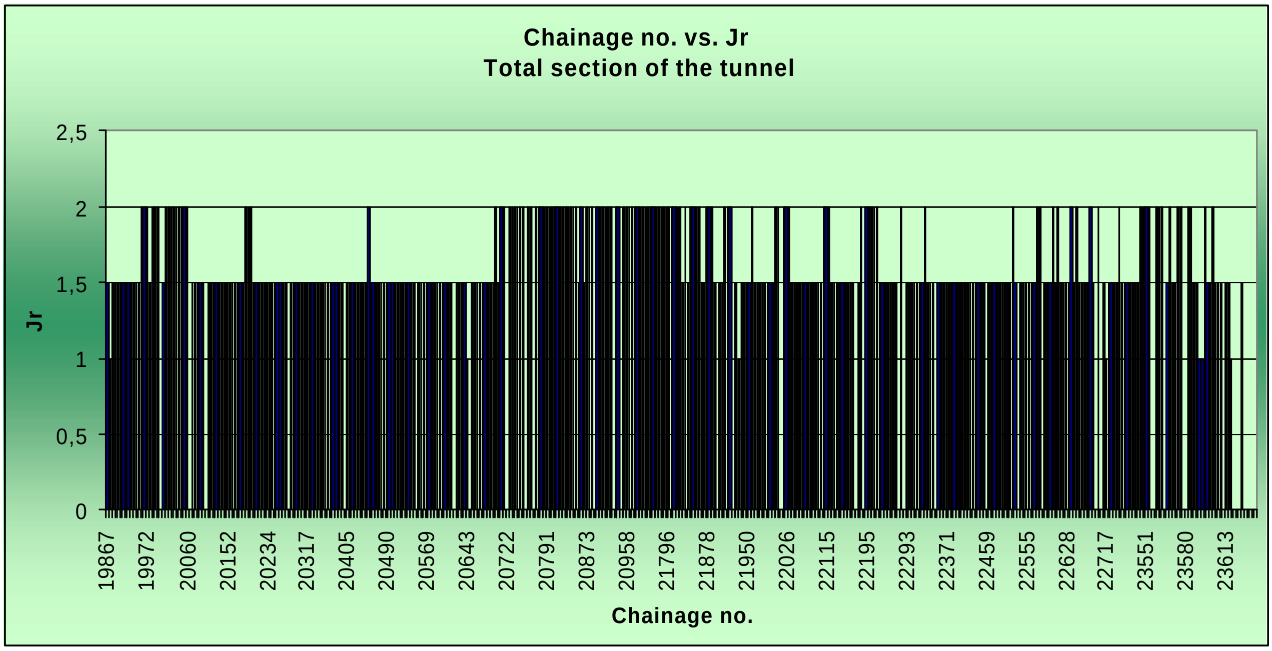


Figure C.8 Presentation of the variation in Jr-value (joint roughness number) compared to chainage number along the tunnel.

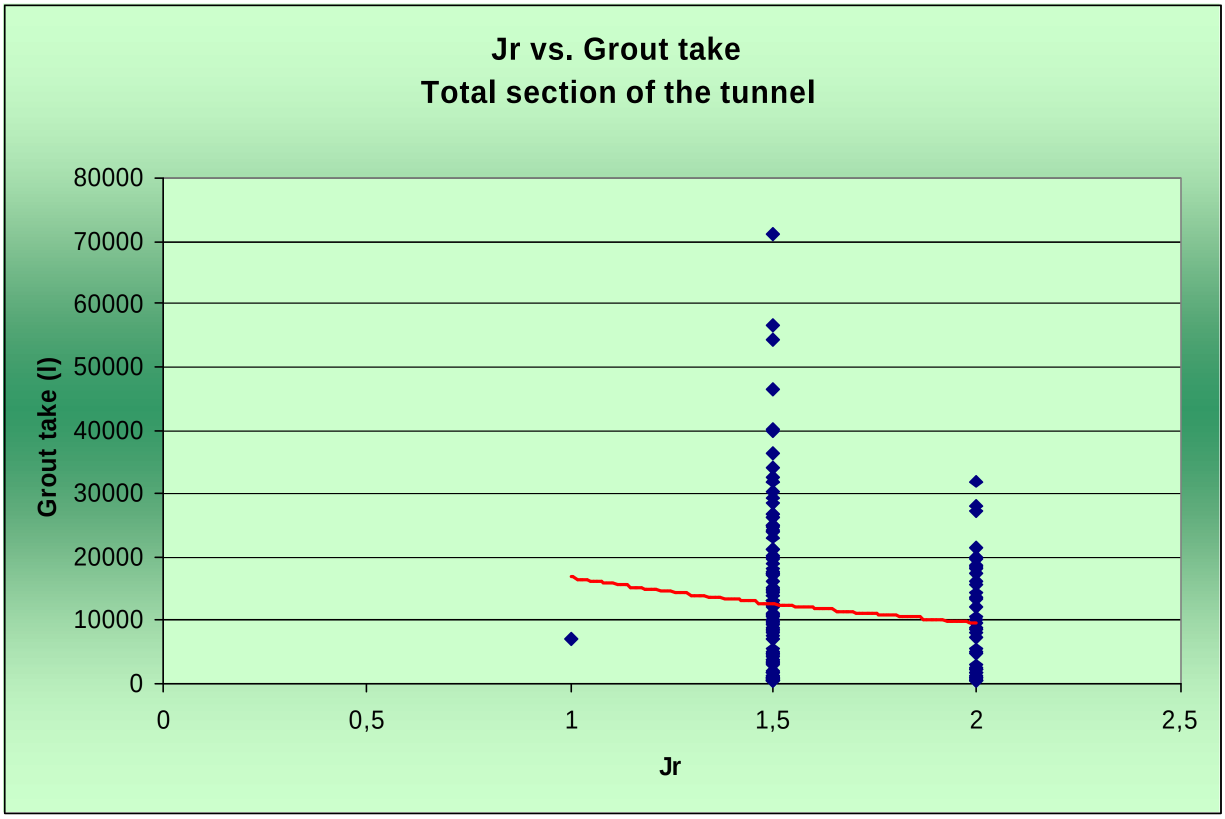


Figure C.9 Presentation of how the Jr-value varies with grout take for the total section of the tunnel.

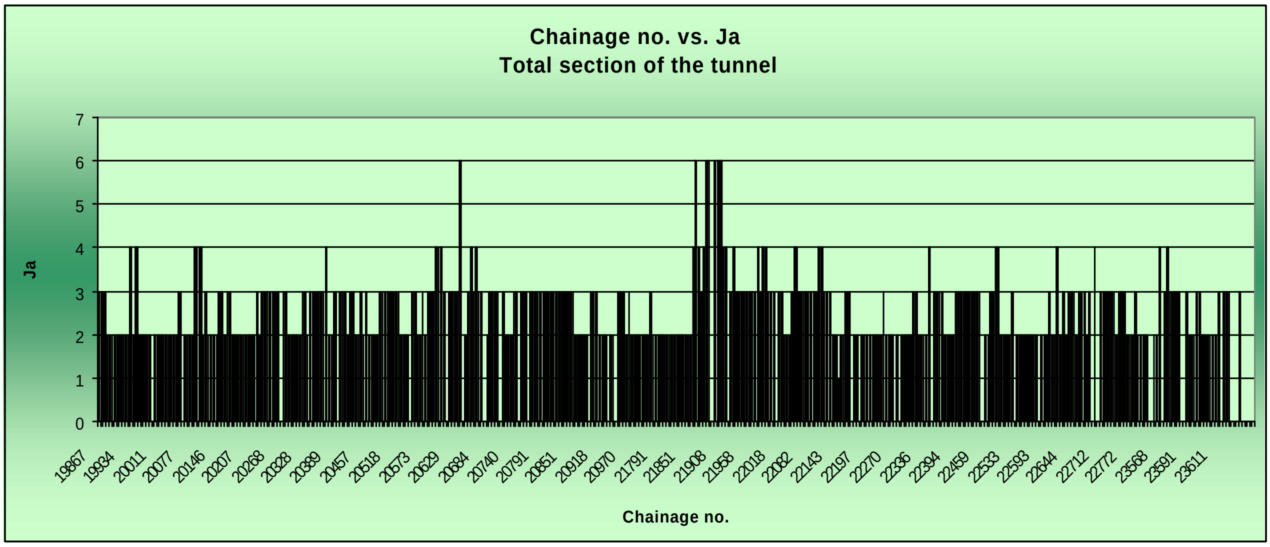


Figure C.10 Presentation of the variation in Ja-value (joint alteration number) compared to chainage number along the tunnel.

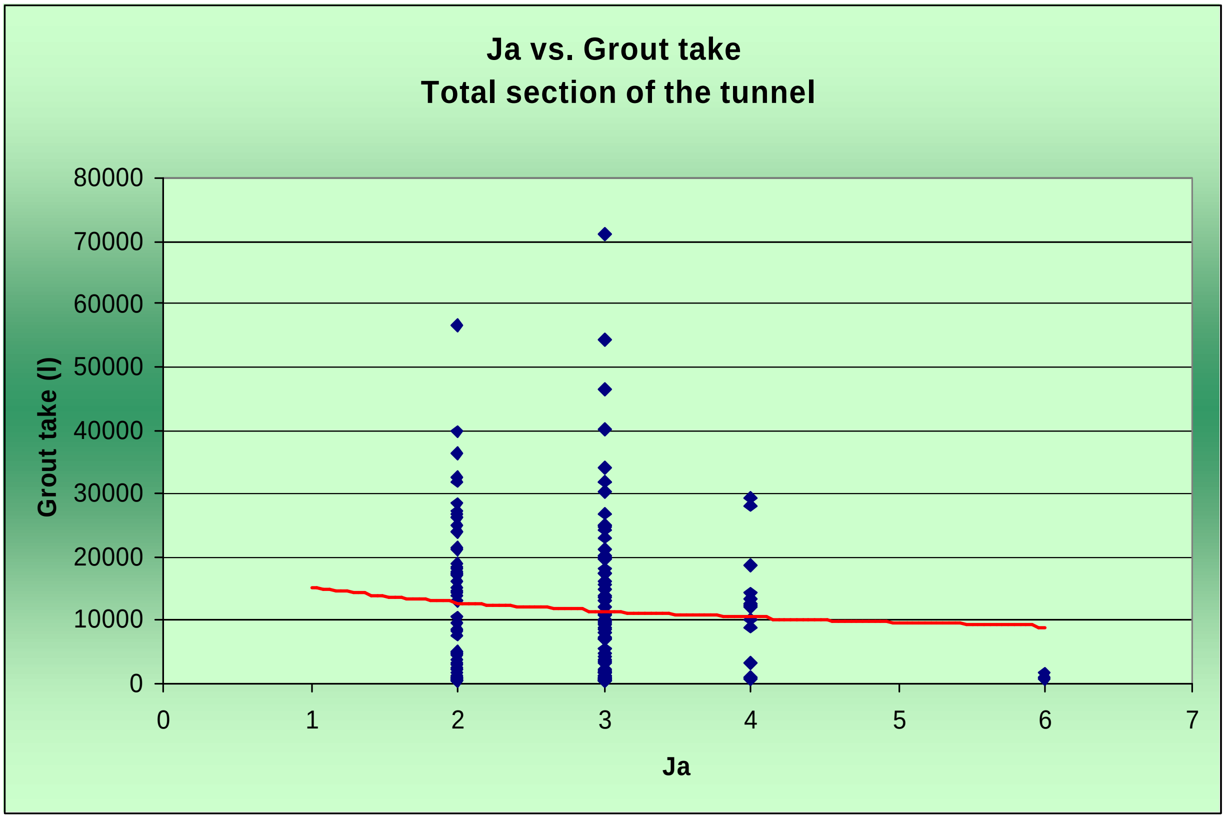


Figure C.11 Presentation of how the Ja-value varies with grout take for the total section of the tunnel.

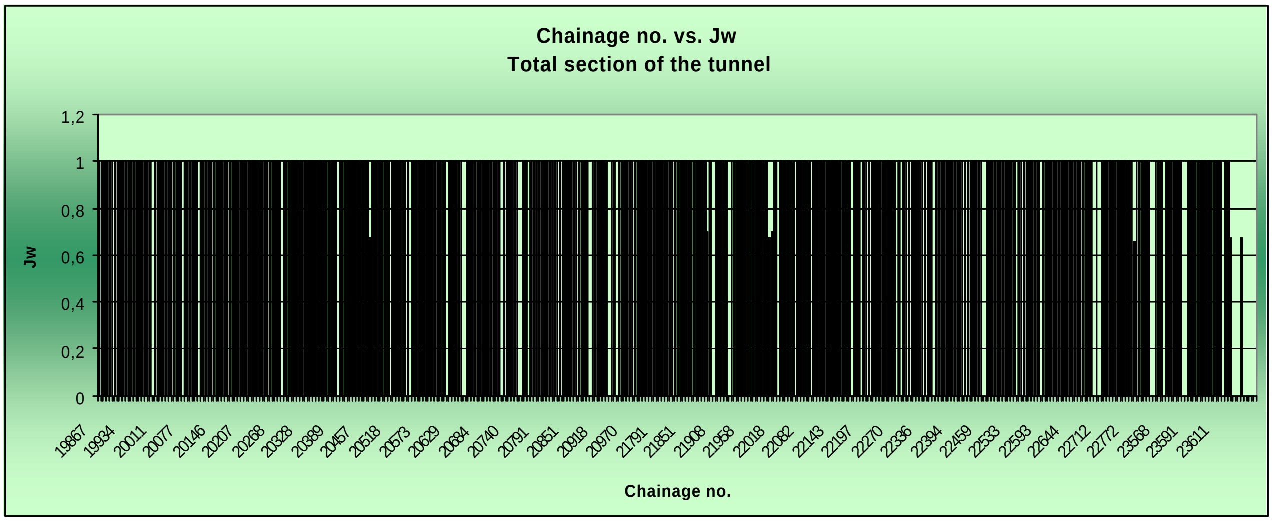


Figure C.12 Presentation of the variation in J_w-value (water conditions) compared to chainage number along the tunnel.

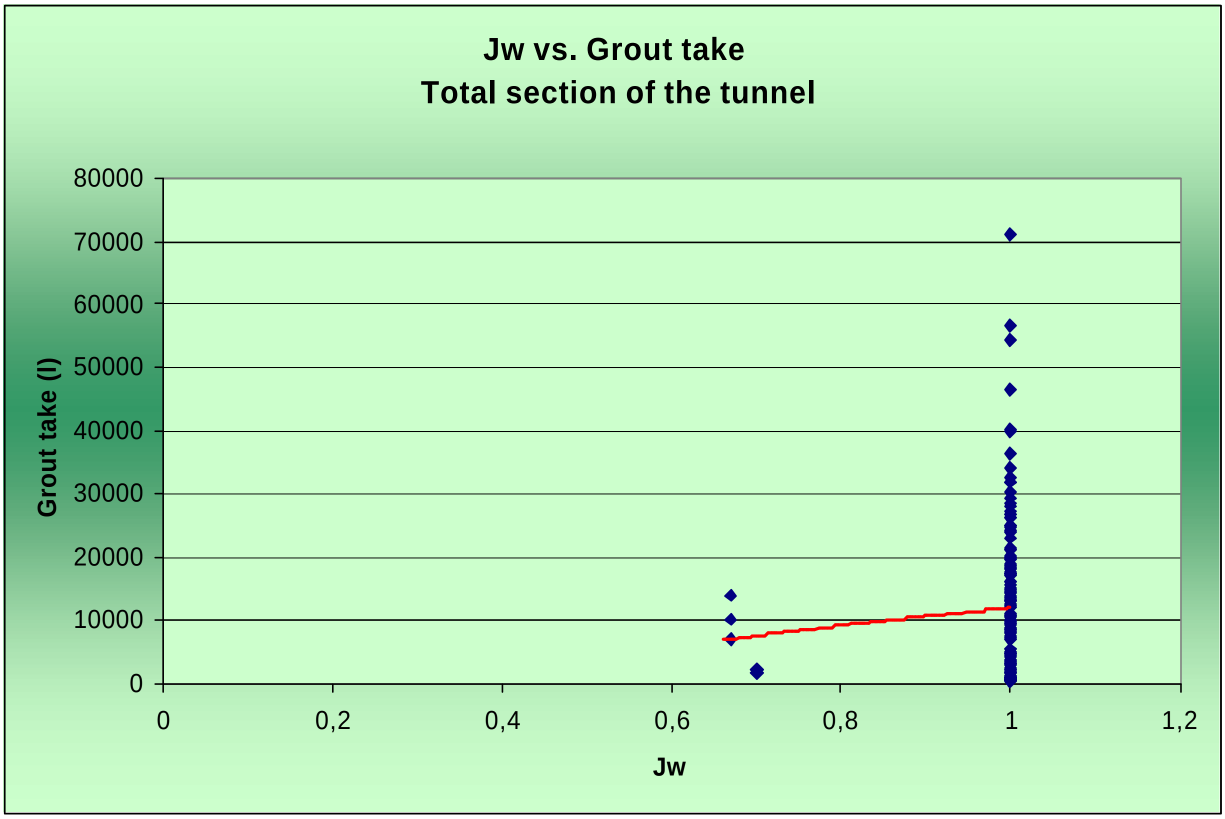


Figure C.13 Presentation of how the J_w-value varies with grout take for the total section of the tunnel.

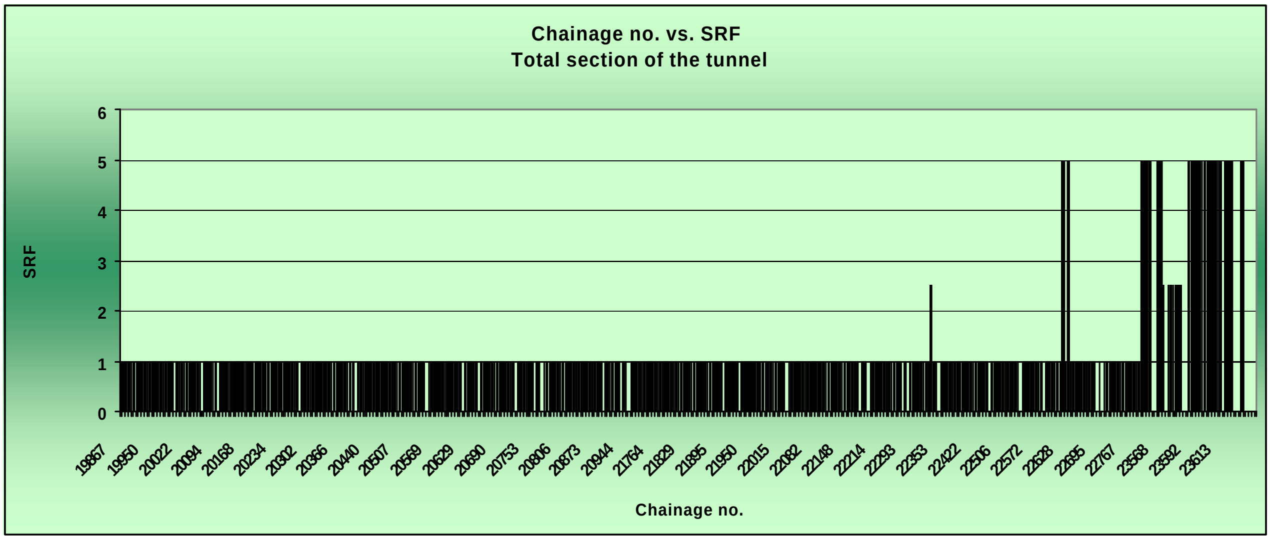


Figure C.14 Presentation of the variation in SRF-value (stress reduction factor) compared to chainage number along the tunnel.

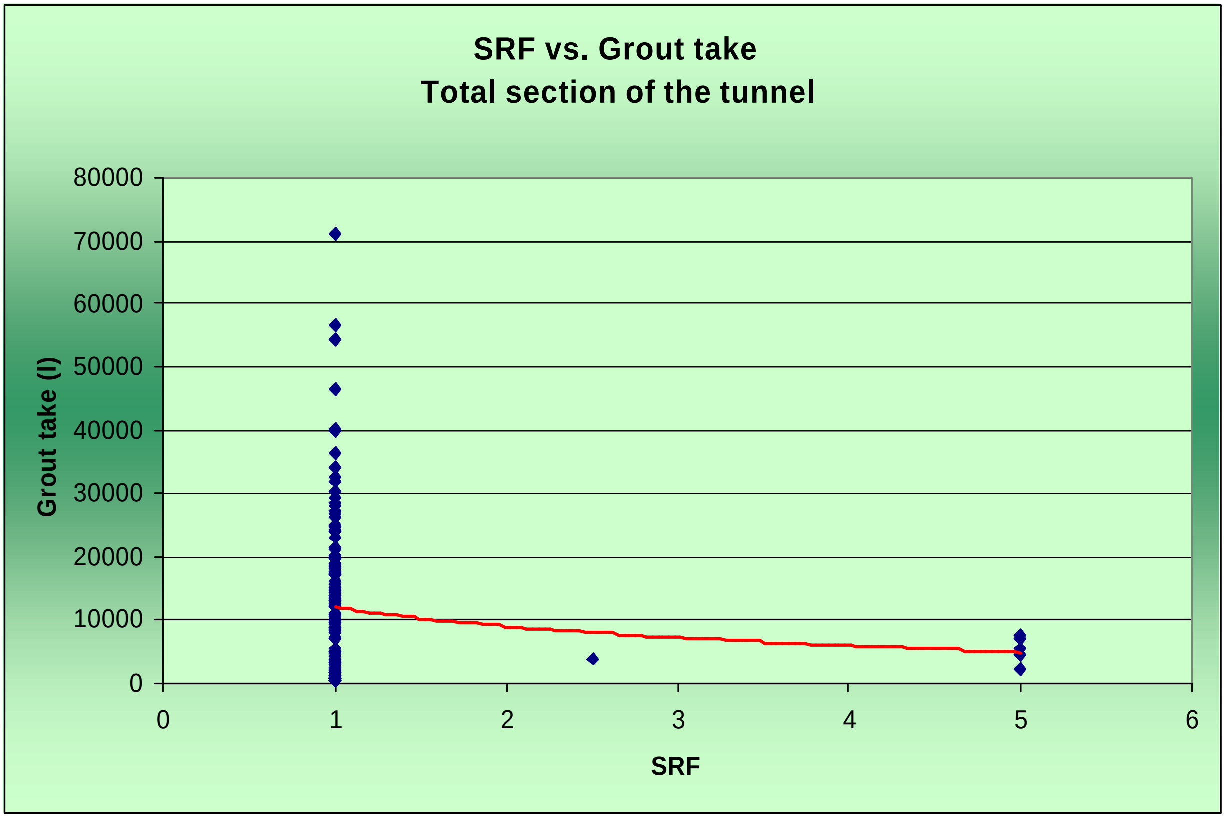


Figure C.15 Presentation of how SRF-value varies with grout take for the total section of the tunnel.

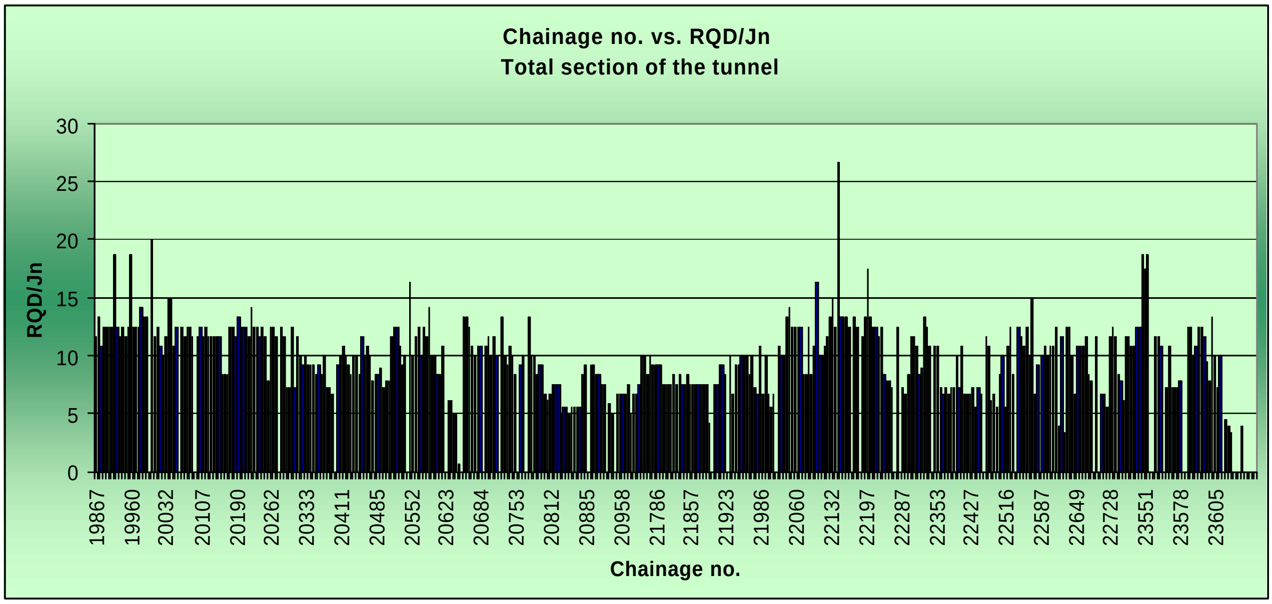


Figure C.16 Presentation of the variation in RQD/ Jn-value (degree of fracturing) compared to chainage number along the tunnel.

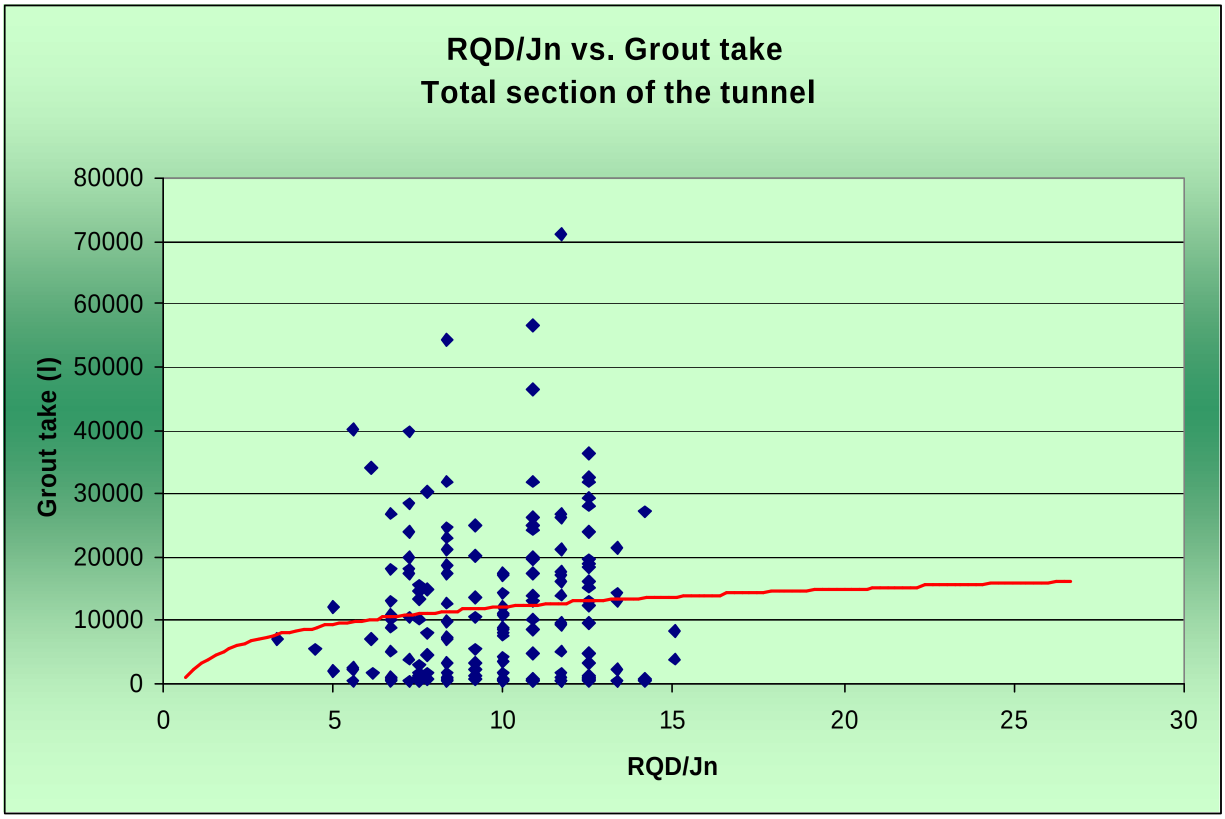


Figure C.17 Presentation of how the RQD/Jn-value varies with grout take for the total section of the tunnel.

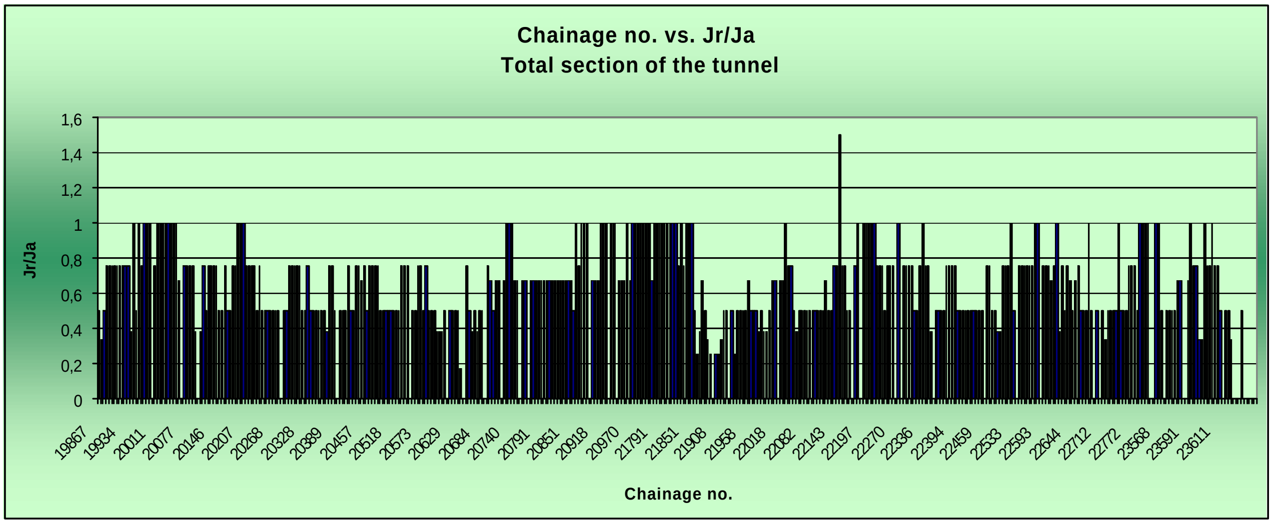


Figure C.18 Presentation of the variation in J_r/J_a-value (shear strength f) compared to chainage number along the tunnel.

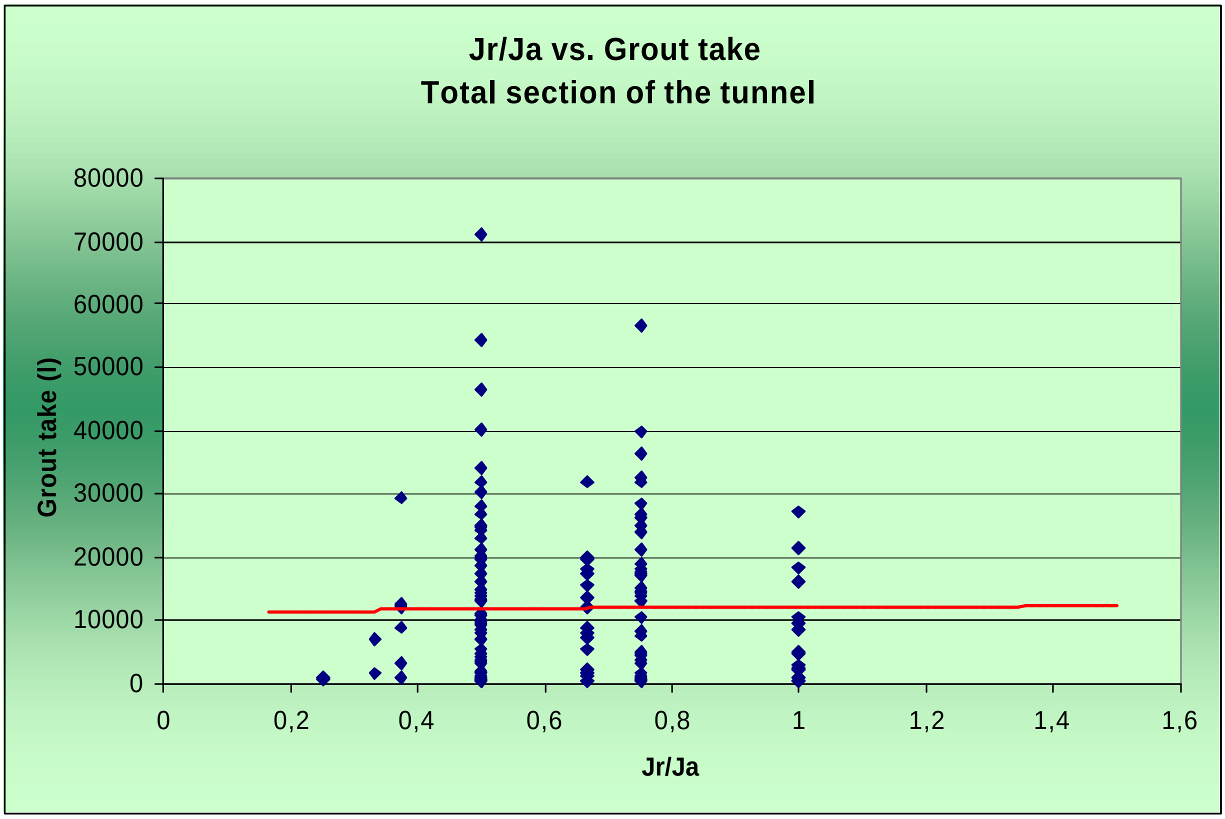


Figure C.19 Presentation of how the J_r/J_a-value varies with grout take for the total section of the tunnel.

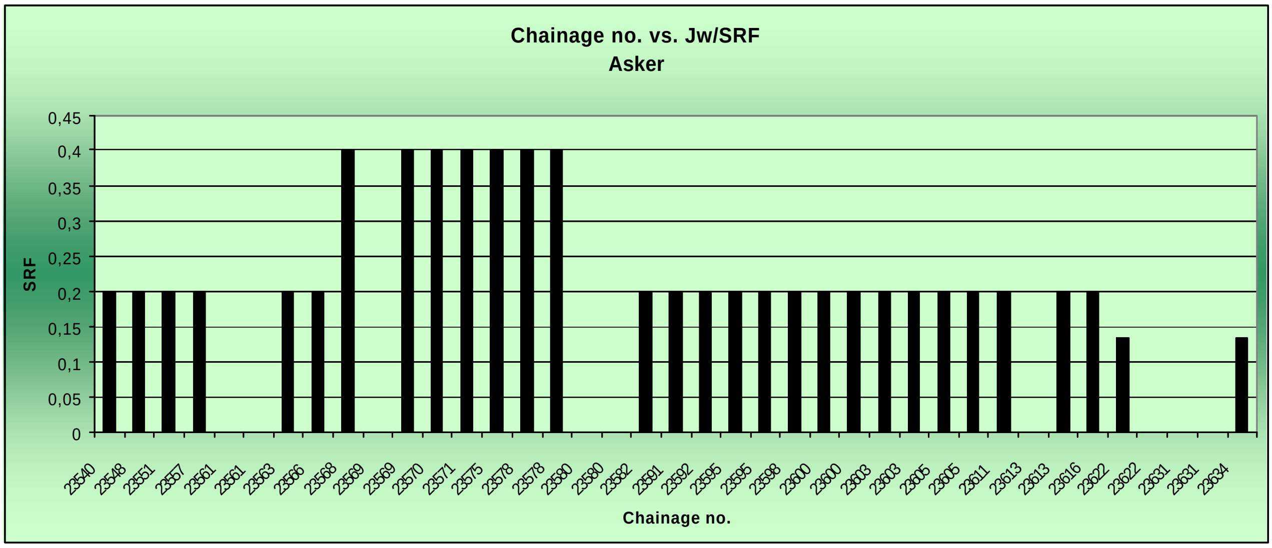


Figure C.20 Presentation of the variation in J_w/SRF-value (stress conditions) compared to chainage number along the tunnel.

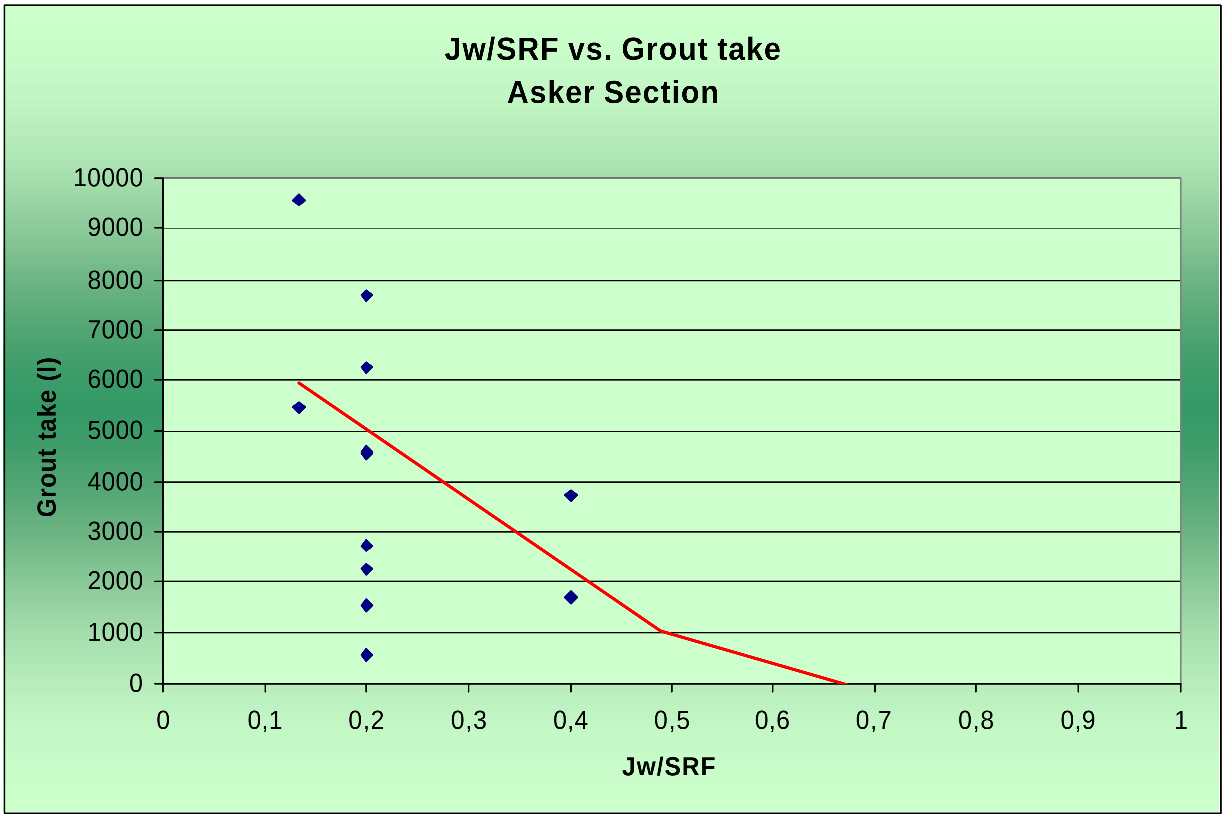


Figure C.21 Presentation of how the J_w/SRF-value varies with grout take for the total section of the tunnel.

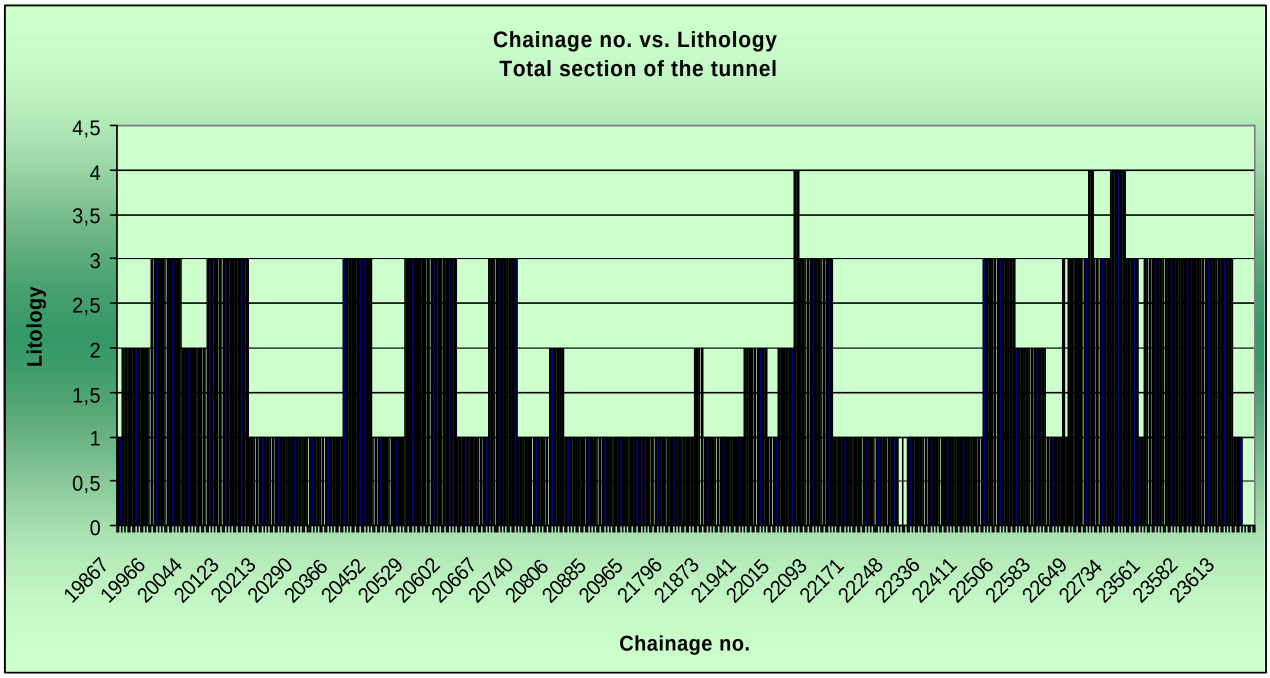


Figure C.22 Presentation of the variation in lithology compared to chainage number along the tunnel.

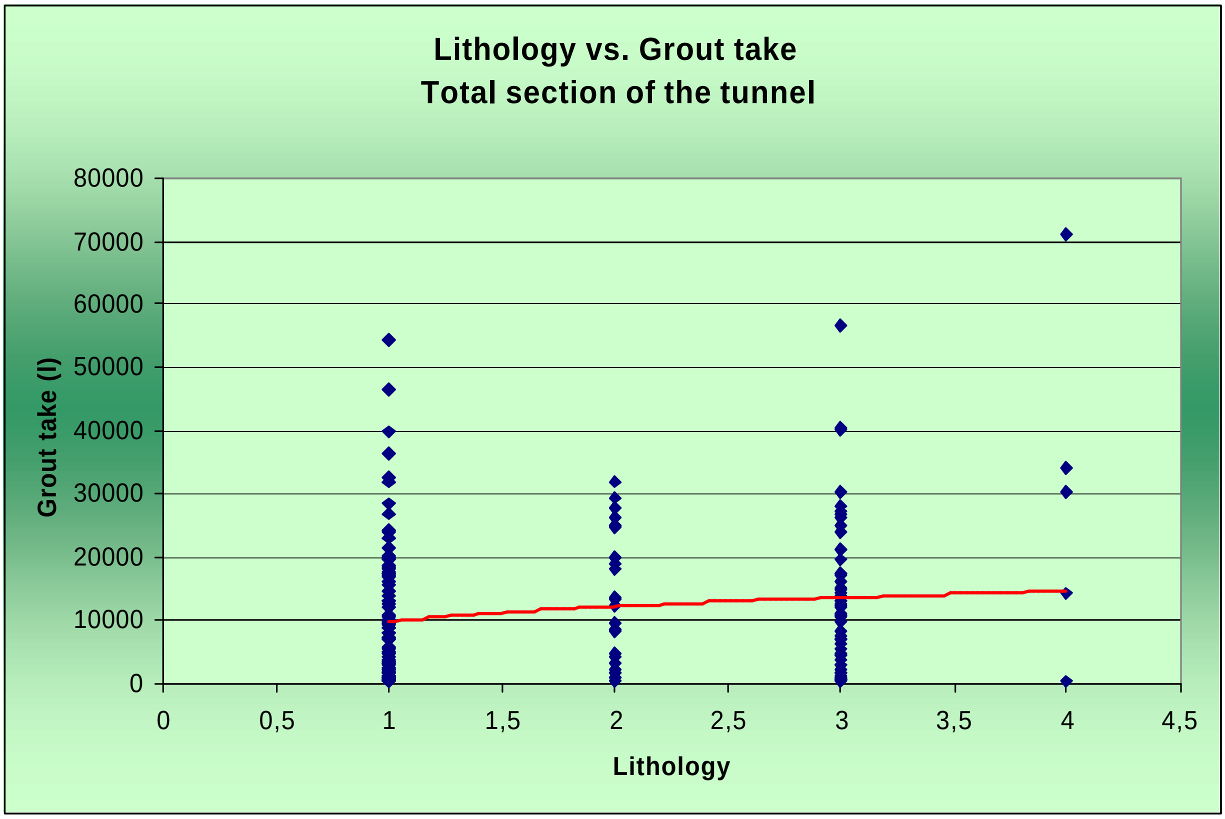


Figure C.23 Presentation of how the lithology varies with grout take for the total section of the tunnel.

Appendix D
Sub-division for structural analysis

Chainage no.	Grout take (L)	Grout pr.m tunnel	Q´-value	RQD	Jn	Jr	Ja	Jw	SRF	RQD/Jn	Jr/Ja	Geology		Comment	Layering strike/dip
19867	9016,2		5,8	70	6	2	3	1	1	11,7	0,5	Nodular Limestone	1	"	set 1: 075/60 set 2: 163/70 set 3: 215/85
19874			4,4	80	6	1	3	1	1	13,3	0,33	Nodular Limestone	1	"	set 1: 070/45 set 2: 163/70 set 3: 215/85
7	9016,2	1 288,0													
19885	25098	24	5,4	65	6	2	3	1	1	10,8	0,5	Claystone	2	Fault! 163/70 5m, diabase 215/85 40cm wide	set 1: 075/45 set 2: 179/85
19890			9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 075/45 set 2: 359/85
5	25098	5019,5													
19895			9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 075/45 set 2: 359/85
19901	31966	15	9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 075/45 set 2: 359/85
19907			9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 075/30 set 2: 359/85
19911			14,1	75	4	2	2	1	1	18,8	0,75	Claystone	2		set 1: 075/30 set 2: 359/85
19917	19120	18	9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 075/30 set 2: 359/85
19923			8,8	70	6	2	2	1	1	11,7	0,75	Claystone	2		set 1: 064/30 set 2: 100/85
19929			9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 064/30 set 2: 100/85
19934	26294	185	8,8	70	6	2	2	1	1	11,7	0,75	Claystone	2		set 1: 064/30 set 2: 100/85
19950	29322	227	4,7	75	6	2	4	1	1	12,5	0,38	Claystone	2		set 1: 250/05 set 2: 148/70
55	106702	1940,0													
19960			18,8	75	4	2	2	1	1	18,8	1	Limestone	3	" 30 cm clay zone 167/80 Fault!	set 1: 250/05 set 2: 148/70
19966	28003	170,5	6,3	75	6	2	4	1	1	12,5	0,5	Limestone	3	"	set 1: 250/05 set 2: 148/90
19972			12,5	75	6	2	2	1	1	12,5	1	Limestone	3	clay filled fractures/fault 167/ 80 30cm wide	set 1: 250/05 set 2: 148/90 set 3: 030/90

19978			9,4	75	6	2	2	1	1	12,5	0,75	Limestone	3		set 1: 250/05 set 2: 148/90
18	28003	1555,7													
19984	27205	314	14,2	85	6	2	2	1	1	14,2	1	Limestone	3		set 1: 250/05 set 2: 148/90
19989			13,3	80	6	2	2	1	1	13,3	1	Limestone	3		set 1: 250/05 set 2: 148/80 set 3: 025/90
19995			13,3	80	6	2	2	1	1	13,3	1	Limestone	3		set 1: 250/10 set 2: 148/80 set 3: 025/90
20000	30214	193										Limestone	3		set 1: 250/20 set 2: 070/70 set 3: 173/90
20005			15,0	80	4	2	2	1	1	20	0,75	Limestone	3		set 1: 250/20 set 2: 070/70 set 3: 320/90
20011			11,7	70	6	2	2	1	1	11,7	1	Limestone	3		set 1: 250/20 set 2: 070/70 set 3: 173/90 set 4: 300/15
20017	16008	71	12,5	75	6	2	2	1	1	12,5	1	Limestone	3		set 1: 250/20 set 2: 070/70 set 3: 173/90 set 4: 300/15
20022			10,8	65	6	2	2	1	1	10,8	1	Limestone	3		set 1: 250/40 set 2: 150/80 set 3: 205/45
20027			10,0	60	6	2	2	1	1	10	1	Claystone	2		set 1: 250/20 set 2: 150/80 set 3: 025/45 set 4: 205/45
20032	9474,2	8,5	11,7	70	6	2	2	1	1	11,7	1	Claystone	2		set 1: 250/20 set 2: 207/10
20039			15,0	60	4	2	2	1	1	15	1	Claystone	2		set 1: 250/20 set 2: 329/90
20044			15,0	60	4	2	2	1	1	15	1	Claystone	2	Calcite layer ll	set 1: 250/20 set 2: 329/90
20048	8661,3	121,5	10,8	65	6	2	2	1	1	10,8	1	Claystone	2		set 1: 250/20 set 2: 329/90
20060			8,3	75	6	2	3	1	1	12,5	0,67	Claystone	2		set 1: 250/30 set 2 :329/90
20065	19867	22										Claystone	2		set 1: 250/30 set 2 :329/90
20071			9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 250/30 set 2 :329/90
20077			8,8	70	6	2	2	1	1	11,7	0,75	Claystone	2		set 1: 250/30 set 2 :329/90
20081	24150	46	9,4	75	6	2	2	1	1	12,5	0,75	Limestone	3		set 1: 250/30 set 2 :329/90
20088			9,4	75	6	2	2	1	1	12,5	0,75	Limestone	3		set 1: 250/45 set 2: 320/90
104	135581	1303,7													
20094			4,4	70	6	2	4	1	1	11,7	0,38	Limestone	3	Fault layer ll	set 1: 250/45
20097	10898	40										Limestone	3	"	set 1: 250/45
20101			4,4	70	6	2	4	1	1	11,7	0,38	Limestone	3	"	set 1: 254/50 set 2: 350/90
20107			9,4	75	6	2	2	1	1	12,5	0,75	Limestone	3	Fault ll layer dip 45	set 1: 254/50 set 2: 000/80 set 3: 032/60

20112	14034	65,5	5,8	70	6	2	3	1	1	11,7	0,5	Limestone	3		set 1: 254/50 set 2: 350/90
18	24932	1385,1													
20117			9,4	75	6	1,5	2	1	1	12,5	0,75	Limestone	3		set 1: 254/50 set 2: 350/90
20123			8,8	70	6	1,5	2	1	1	11,7	0,75	Limestone	3		set 1: 254/50 set 2: 350/90
20130	17040	145	8,8	70	6	1,5	2	1	1	11,7	0,75	Limestone	3		set 1: 254/50 set 2: 350/90
20146	26942	167	8,8	70	6	2	2	1	1	11,7	0,75	Limestone	3		set 1: 254/50 set 2: 350/90
20152			5,8	70	6	2	3	1	1	11,7	0,5	Limestone	3		set 1: 254/50 set 2: 350/90
20157			5,8	70	6	2	3	1	1	11,7	0,5	Limestone	3		set 1: 254/50 set 2: 008/80
40	43982	1099,5													
20163	21105		6,3	75	9	2	2	1	1	8,33	0,75	Limestone	3	dike layer ll	set 1: 258/50 set 2: 190/90 set 3: 008/30
20168			4,2	75	9	2	3	1	1	8,33	0,5	Limestone	3		set 1: 258/50 set 2: 190/90 set 3: 008/30
5,5	21105	3837,3													
20168			4,2	75	9	2	3	1	1	8,33	0,5	Limestone	3		set 1: 258/50 set 2: 190/90 set 3: 008/30
20173	350		4,2	75	9	2	3	1	1	8,33	0,5	Limestone	3		set 1: 258/50 set 2: 190/90 set 3: 008/30
20178	36436	119,5	9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1		set 1: 258/50 set 2: 190/90 set 3: 008/30 set 4: 248/70
20185			9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1		set 1: 258/60 set 2: 190/50
20190	460		11,7	70	6	2	2	1	1	11,7	1	Nodular Limestone	1		set 1: 258/60 set 2: 190/50
22	37246	1693													
20196	21353		13,3	80	6	2	2	1	1	13,3	1	Nodular Limestone	1	clay filled fracture ll layering	set 1: 252/80 set 2: 091/60
20201			12,5	75	6	2	2	1	1	12,5	1	Nodular Limestone	1		set 1: 252/80 set 2: 091/60
20207	546,3		9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1	Q´=9,2	set 1: 252/80 set 2: 091/60
20213	32456		9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1		set 1: 254/50 set 2: 172/70
20218			8,8	70	6	2	2	1	1	11,7	0,75	Nodular	1		set 1: 254/50 set 2: 172/70

												Limestone			
20222	565		10,6	85	6	2	2	1	1	14,2	0,75	Nodular Limestone	1		set 1: 254/50 set 2: 172/70 set 3: 095/60
20229	9447,5		6,3	75	6	2	3	1	1	12,5	0,5	Nodular Limestone	1		set 1: 254/50 set 2: 172/70 set 3: 095/60
33	64368	1950,5													
20234			9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1	dike 354/80 clay 095/60	set 1: 254/50 set 2: 172/70 set 3: 095/60
20239	1459,4		5,8	70	6	2	3	1	1	11,7	0,5	Nodular Limestone	1		set 1: 254/70
20245			6,3	75	6	2	3	1	1	12,5	0,5	Nodular Limestone	1		set 1: 254/70
6	1459,4	243,2													
20250	16245	26	5,8	70	6	2	3	1	1	11,7	0,5	Nodular Limestone	1	Dike 352/70 cut by fault 261/75	set 1: 254/70
20256	640		3,9	70	9	2	3	1	1	7,78	0,5	Nodular Limestone	1		set 1: 254/70
6	16885	2814,1													
20256	640		3,9	70	9	2	3	1	1	7,78	0,5	Nodular Limestone	1		set 1: 254/70
20262	12916	34	6,3	75	6	2	3	1	1	12,5	0,5	Nodular Limestone	1		set 1: 254/70
20268			6,3	75	6	2	3	1	1	12,5	0,5	Nodular Limestone	1		set 1: 254/70
20274	369,3		5,8	70	6	2	3	1	1	11,7	0,5	Nodular Limestone	1		set 1: 254/70
20280	12715	6										Nodular Limestone	1		set 1: 254/70
20284			6,3	75	6	2	3	1	1	12,5	0,5	Nodular Limestone	1		set 1: 254/70
20290	381,1		5,8	70	6	2	3	1	1	11,7	0,5	Nodular Limestone	1		set 1 :255/60 set 2: 120/90
34	27021	794,7													

20295	17534	5,5	5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1	dike 031/90	set 1 :255/60 set 2: 120/90
20302			5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1		set 1 :255/60 set 2: 120/90
6,5	17534	2697,5													
20302			5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1		set 1 :255/60 set 2: 120/90
20307	859,1		9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1	Fault 255/60	set 1: 255/60
5	859,1	171,8													
20312	23992	10,5	5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1		set 1: 255/60
20317			8,8	70	6	2	2	1	1	11,7	0,75	Nodular Limestone	1		set 1: 255/60
20323	232,1		5,0	60	6	2	3	1	1	10	0,5	Nodular Limestone	1	center fold axis 254/60	set 1: 083/70 set 2: 122/90
20328			4,6	55	6	2	3	1	1	9,17	0,5	Nodular Limestone	1		set 1: 083/70 set 2: 122/90
20333	17497	205	7,5	60	6	2	2	1	1	10	0,75	Nodular Limestone	1		set 1: 083/70 set 2: 122/90
20339	3203,4	12	4,6	55	6	2	3	1	1	9,17	0,5	Nodular Limestone	1		set 1: 083/70 set 2: 122/90
20344			4,6	55	6	2	3	1	1	9,17	0,5	Nodular Limestone	1		set 1: 083/70 set 2: 122/90
20350	20277	389	4,6	55	6	2	3	1	1	9,17	0,5	Nodular Limestone	1		set 1: 083/70 set 2: 122/90
20355			4,2	50	6	2	3	1	1	8,33	0,5	Nodular Limestone	1		set 1: 083/70 set 2: 122/90
20361			4,6	55	6	2	3	1	1	9,17	0,5	Nodular Limestone	1		set 1: 083/70 set 2: 122/90
20366	6878,8	73	4,2	50	6	2	3	1	1	8,33	0,5	Nodular Limestone	1		set 1: 083/70 set 2: 122/90
20372			3,8	60	6	2	4	1	1	10	0,38	Nodular Limestone	1	" "	set 1: 083/70 set 2: 122/90
60	72080	1201,3													
20377	10475	18	5,4	65	9	2	2	1	1	7,22	0,75	Limestone	3	" Fault 083/50	set 1: 083/70
20384			5,4	65	9	2	2	1	1	7,22	0,75	Limestone	3	dike 335/90 0,2m	set 1: 083/70

6,5	10475	1611,5													
20389	633,8		3,3	60	9	2	3	1	1	6,67	0,5	Limestone	3		set 1: 083/70
20395	7077,3	5										Limestone	3		set 1: 083/70
20405	666		4,6	55	6	2	3	1	1	9,17	0,5	Limestone	3		set 1: 083/70
20411	10940		5,0	60	6	2	3	1	1	10	0,5	Limestone	3		set 1: 083/70
20418	257		5,4	65	6	2	3	1	1	10,8	0,5	Limestone	3		set 1: 083/70
20423			7,5	60	6	2	2	1	1	10	0,75	Limestone	3		set 1: 083/70
20429	1133,6		4,6	55	6	2	3	1	1	9,17	0,5	Limestone	3		set 1: 083/70
39,5	20708	524,3													
20435			4,2	50	6	2	3	1	1	8,33	0,5	Limestone	3	"	set 1: 083/70
20440			7,5	60	6	2	2	1	1	10	0,75	Limestone	3	Fault layer II	set 1: 082/70 set 2: 176/90
20445	595,2		7,5	60	6	2	2	1	1	10	0,75	Nodular Limestone	1		set 1: 082/70 set 2: 176/90
20452	31991	11	5,6	50	6	2	3	1	1	8,33	0,67	Nodular Limestone	1		set 1: 082/70 set 2: 176/90
20457			8,8	70	6	2	2	1	1	11,7	0,75	Nodular Limestone	1		set 1: 082/70 set 2: 176/90
20463	1636,4	0,4	5,0	60	6	2	3	1	1	10	0,5	Nodular Limestone	1		set 1: 082/70 set 2: 176/90
20469	13863	145	5,4	65	6	2	2	1	1	10,8	0,75	Nodular Limestone	1	center fold axis	set 1: 251/10
20474			7,5	60	6	2	2	1	1	10	0,75	Nodular Limestone	1		set 1: 251/20
20479			5,8	70	9	2	2	1	1	7,78	0,75	Nodular Limestone	1		set 1: 251/20
20485	3292,9	21	6,3	75	9	2	2	1	1	8,33	0,75	Nodular Limestone	1		set 1: 250/30 set 2: 176/85 set 3: 060/60
20490	54483	860	4,2	75	9	2	3	1	1	8,33	0,5	Nodular Limestone	1		set 1: 250/30 set 2: 176/85 set 3: 060/60
20495			4,4	80	9	2	3	1	1	8,89	0,5	Nodular Limestone	1		set 1: 250/30 set 2: 176/85
20501			3,6	65	9	2	3	1	1	7,22	0,5	Nodular Limestone	1		set 1: 250/30 set 2: 176/85
20507	7831,2	16	3,9	70	9	2	3	1	1	7,78	0,5	Nodular Limestone	1		set 1: 250/30 set 2: 176/85

62	113693	1833,8													
20512	14765	548	3,9	70	9	2	3	1	1	7,78	0,5	Limestone	3		set 1: 250/30 set 2: 176/85
20518			5,8	70	6	2	3	1	1	11,7	0,5	Limestone	3		set 1: 250/30 set 2: 176/85
20524			6,3	75	6	2	3	1	1	12,5	0,5	Limestone	3		set 1: 250/30 set 2: 130/90
20529	4608	13	6,3	75	6	2	3	1	1	12,5	0,5	Limestone	3		set 1: 250/30 set 2: 130/90
20535	25136	87	8,1	65	6	2	2	1	1	10,8	0,75	Limestone	3		set 1: 250/30 set 2: 130/90
20541			6,9	55	6	2	2	1	1	9,17	0,75	Limestone	3		set 1: 250/30 set 2: 130/90
20547			7,5	60	6	2	2	1	1	10	0,75	Limestone	3		set 1: 250/30 set 2: 130/90
20551	765,3	55,5										Limestone	3		set 1: 250/30 set 2: 130/90
20552			8,1	65	4	2	3	1	1	16,3	0,5	Limestone	3		set 1: 250/30 set 2: 130/90
20556	10671	50	5,0	60	6	2	3	1	1	10	0,5	Limestone	3		set 1: 250/30 set 2: 130/90
20563			8,8	70	6	2	2	1	1	11,7	0,75	Limestone	3		set 1: 255/30 set 2: 120/85
20569			9,4	75	6	2	2	1	1	12,5	0,75	Limestone	3		set 1: 255/30 set 2: 120/85
20573	585,9		5,0	60	6	2	3	1	1	10	0,5	Limestone	3		set 1: 255/30 set 2: 120/85
20579	15321	7	9,4	75	6	2	2	1	1	12,5	0,75	Limestone	3		set 1: 255/30 set 2: 120/85
20585			5,8	70	6	2	3	1	1	11,7	0,5	Limestone	3		set 1: 255/30 set 2: 120/85
20591			7,1	85	6	2	3	1	1	14,2	0,5	Limestone	3		set 1: 255/30 set 2: 355/75-90
20595	1458		5,0	60	6	2	3	1	1	10	0,5	Limestone	3		set 1: 255/30 set 2: 355/75-90
20602	12016	23	3,8	60	6	2	4	1	1	10	0,38	Limestone	3		set 1: 255/30 set 2: 355/75-90
20607			3,1	50	6	2	4	1	1	8,33	0,38	Limestone	3	"	set 1: 255/30 set 2: 355/75-90
78	85327	1093,9													
20613			3,1	50	6	2	4	1	1	8,33	0,38	Limestone	3	Fault layer ll dip 60	set 1: 255/30 set 2: 355/75-90
20618	408		5,4	65	6	2	3	1	1	10,8	0,5	Nodular Limestone	1		set 1: 255/30 set 2: 355/75-90
20623	23065	2										Nodular Limestone	1		set 1: 255/30 set 2: 355/75-90
5	23473	4694,5													
20624			3,1	55	9	2	3	1	1	6,11	0,5	Nodular Limestone	1	1m diabase 255/60	set 1: 255/30 set 2: 355/75-90

20629			3,1	55	9	2	3	1	1	6,11	0,5	Nodular Limestone	1		set 1: 255/30
20634			2,5	45	9	2	3	1	1	5	0,5	Nodular Limestone	1		set 1: 255/30
20640	1924,6	4	2,5	45	9	2	3	1	1	5	0,5	Nodular Limestone	1		set 1: 255/30
11	1924,6	175,0													
20643			0,1	10	15	1	6	1	1	0,67	0,17	Nodular Limestone	1	3 m wide fault 247/ 80	set 1: 255/75 set 2: 355/90
20646	19644	54										Nodular Limestone	1		set 1: 255/75 set 2: 355/90
20649			10,0	80	6	2	2	1	1	13,3	0,75	Nodular Limestone	1		set 1: 255/75 set 2: 355/90
20655			6,7	80	6	2	3	1	1	13,3	0,5	Nodular Limestone	1		set 1: 255/75 set 2: 355/90
20661	3077,5	49,1	4,7	75	6	2	4	1	1	12,5	0,38	Nodular Limestone	1		set 1: 255/75 set 2: 355/90
20667	10124	100	5,4	65	6	2	3	1	1	10,8	0,5	Nodular Limestone	1		set 1: 255/75 set 2: 355/90
21,5	32846	1527,7													
20673			3,8	60	6	2	4	1	1	10	0,38	Limestone	3		set 1: 255/75 set 2: 355/90
20678			5,4	65	6	2	3	1	1	10,8	0,5	Limestone	3	clay filled fractures 300/50	set 1: 255/75 set 2: 355/90
20684			5,4	65	6	2	3	1	1	10,8	0,5	Limestone	3	calcite ll layering	set 1: 255/75 set 2: 355/90
20690	2998					2		1	1			Limestone	3		set 1: 255/75 set 2: 355/90
20696			8,1	65	6	2	2	1	1	10,8	0,75	Limestone	3		set 1: 255/75 set 2: 355/90
20701			7,8	70	6	2	3	1	1	11,7	0,67	Limestone	3	Fault ll layerdeling	set 1: 255/75 set 2: 355/90
20707			5,0	60	6	2	3	1	1	10	0,5	Limestone	3	Fault ll set 1 0,2m	set 1: 255/75 set 2: 355/90
33,5	2998	89,5													

20713			7,8	70	6	2	3	1	1	11,7	0,67	Limestone	3		set 1: 255/75 set 2: 355/90
20719			6,7	60	6	2	3	1	1	10	0,67	Limestone	3		set 1: 255/75 set 2: 355/90
20722	7094,5											Limestone	3		set 1: 255/75 set 2: 355/90
20724			8,9	80	6	2	3	1	1	13,3	0,67	Limestone	3		set 1: 260/60 set 2: 200/90 set 3: 330/90
20730			10,0	60	6	2	2	1	1	10	1	Nodular Limestone	1		set 1: 260/60 set 2: 200/90 set 3: 330/90
20735	10288		9,2	55	6	2	2	1	1	9,17	1	Nodular Limestone	1		set 1: 260/60 set 2: 200/90 set 3: 330/90
20740			10,8	65	6	2	2	1	1	10,8	1	Nodular Limestone	1		set 1: 260/60 set 2: 200/90 set 3: 330/90
20746			6,7	60	6	2	3	1	1	10	0,67	Nodular Limestone	1		set 1: 260/70
20753	406,3		5,6	50	6	2	3	1	1	8,33	0,67	Nodular Limestone	1		set 1: 260/70 set 2: 034/10
20756	4053,2	17										Nodular Limestone	1	clay filled fractures layer ll	set 1: 260/70 set 2: 034/10
20758			6,1	55	6	2	3	1	1	9,17	0,67	Nodular Limestone	1		set 1: 260/70 set 2: 034/10
20763			6,7	60	6	2	3	1	1	10	0,67	Nodular Limestone	1		set 1: 260/70 set 2: 034/10 set 3: 350/?
50	21842	436,8													

20769	3159,6		8,9	80	6	2	3	1	1	13,3	0,67	Nodular Limestone	1	fault ~260/60 clay + ll set 2	set 1: 260/80 set 2: 034/10
20775		30	6,7	60	6	2	3	1	1	10	0,67	Nodular Limestone	1		set 1: 260/80 set 2: 034/10
6,5	3159,6	486,1													

20775	8827,4	30	6,7	60	6	2	3	1	1	10	0,67	Nodular Limestone	1		set 1: 260/80 set 2: 034/10
20780			6,7	60	6	2	3	1	1	10	0,67	Nodular Limestone	1		set 1: 260/80 set 2: 106/90
20786	1702,2	28	5,6	50	6	2	3	1	1	8,33	0,67	Claystone	2		set 1: 260/80 set 2: 034/10
11	10530	957,2													

20791	13541	90	6,1	55	6	2	3	1	1	9,17	0,67	Claystone	2	fault layer ll 3m	set 1: 260/60 set 2: 350/80 set 3: 118/45
20796			6,1	55	6	2	3	1	1	9,17	0,67	Claystone	2		set 1: 260/60 set 2: 350/80 set 3:

															118/45
20801			4,4	40	6	2	3	1	1	6,67	0,67	Claystone	2		set 1: 260/60 set 2: 350/80
20806	1589,2		4,1	37	6	2	3	1	1	6,17	0,67	Claystone	2	Fault 093/45	set 1: 260/60 set 2: 350/80 set 3: 093/45
15	15130	1008,7													
20812	18032	76	4,4	40	6	2	3	1	1	6,67	0,67	Claystone	2		set 1: 260/60 set 2: 350/80 set 3: 118/60
20818			5,0	45	6	2	3	1	1	7,5	0,67	Nodular Limestone	1		set 1: 260/60
20824	454,6		5,0	45	6	2	3	1	1	7,5	0,67	Nodular Limestone	1		set 1: 260/50
20830	15580	90	5,0	45	6	2	3	1	1	7,5	0,67	Nodular Limestone	1		set 1: 260/50
20835			3,3	45	9	2	3	1	1	5	0,67	Nodular Limestone	1		set 1: 260/50 set 2: 350/90
20840			3,7	50	9	2	3	1	1	5,56	0,67	Nodular Limestone	1		set 1: 260/50 set 2: 350/90
20846			3,7	50	9	2	3	1	1	5,56	0,67	Nodular Limestone	1		set 1: 260/60
20851	11940		3,3	45	9	2	3	1	1	5	0,67	Nodular Limestone	1		set 1: 260/60
39	46007	1179,7													
20857			2,8	50	9	2	3	1	1	5,56	0,5	Nodular Limestone	1	fault layer ll	set 1: 260/60 set 2: 170/80
20862			5,6	50	9	2	2	1	1	5,56	1	Nodular Limestone	1		set 1 :255/70 set 2: 170/80
20867			4,2	50	9	2	2	1	1	5,56	0,75	Nodular Limestone	1		set 1 :255/70 set 2: 170/80
20873	2584,5		5,6	50	9	2	2	1	1	5,56	1	Nodular Limestone	1		set 1 :255/70 set 2: 170/80
20879			8,3	50	6	2	2	1	1	8,33	1	Nodular Limestone	1	Fault! 075/50	set 1 :255/70 set 2: 170/80
20885			9,2	55	6	2	2	1	1	9,17	1	Nodular Limestone	1	Fault! 082/50	set 1 :255/70 set 2: 170/80
20890	6837,8											Nodular Limestone	1		set 1 :255/70 set 2: 170/80
20901			6,1	55	6	2	3	1	1	9,17	0,67	Nodular Limestone	1	calcite ll set 2	set 1 :255/70 set 2: 170/80
20906	5248,9		6,1	55	6	2	3	1	1	9,17	0,67	Nodular	1	Fault 170/85 ll	set 1: 254/70

												Limestone		tunneltrace	
49,5	14671	296,4													
20911	7183,2	2	5,6	50	6	2	3	1	1	8,33	0,67	Nodular Limestone	1	clay filled fractures/fault 255/60	set 1: 254/70
20918			8,3	50	6	2	2	1	1	8,33	1	Nodular Limestone	1		set 1: 254/70
20925	445	25	7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1		set 1: 255/70 set 2: 149/30
20928			7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1		set 1: 255/70 set 2: 149/30
20933	5665												1	clay filled fractures layer II	set 1: 255/70 set 2: 149/30 set 3: 255/30
22	13293	604,2													
20939			5,8	35	6	2	2	1	1	5,83	1	Nodular Limestone	1		set 1: 255/70 set 2: 255/30
20944			5,0	30	6	2	2	1	1	5	1	Nodular Limestone	1		set 1: 255/70 set 2: 255/30
20949	16876												1		set 1: 255/70 set 2: 255/30
20955			4,4	40	6	2	3	1	1	6,67	0,67	Nodular Limestone	1		set 1: 255/70 set 2: 350/80
20958			4,4	40	6	2	3	1	1	6,67	0,67	Nodular Limestone	1		set 1: 255/70 set 2 350/80
20965			4,4	40	6	2	3	1	1	6,67	0,67	Nodular Limestone	1		set 1: 248/80 set 2: 350/80
20967			6,7	40	6	2	2	1	1	6,67	1	Nodular Limestone	1		set 1: 248/80 set 2: 350/80
20970	1267,1		5,0	45	6	2	3	1	1	7,5	0,67	Nodular Limestone	1		set 1: 248/80 set 2: 350/80
20977			5,0	30	6	2	2	1	1	5	1	Nodular Limestone	1		set 1: 248/80 set 2: 350/80
20982			6,7	40	6	2	2	1	1	6,67	1	Nodular Limestone	1		set 1: 248/80 set 2: 350/80
20987			6,7	40	6	2	2	1	1	6,67	1	Nodular Limestone	1	calcite II set 2	set 1: 248/80 set 2: 350/80
20993	1045,8		7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1		set 1: 248/80 set 2: 350/80
20998			10,0	60	6	2	2	1	1	10	1	Nodular	1		set 1: 258/70 set 2: 178/90

												Limestone			
59	19188	325,2													
21764			10,0	60	6	2	2	1	1	10	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21770			8,3	50	6	2	2	1	1	8,33	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21775	7798,5		6,7	60	6	2	3	1	1	10	0,67	Nodular Limestone	1		set 1: 255/75
21781			9,2	55	6	2	2	1	1	9,17	1	Nodular Limestone	1		set 1: 255/75
21786			9,2	55	6	2	2	1	1	9,17	1	Nodular Limestone	1		set 1: 255/75
21791			9,2	55	6	2	2	1	1	9,17	1	Nodular Limestone	1		set 1: 255/75
21796	2279,4		9,2	55	6	2	2	1	1	9,17	1	Nodular Limestone	1		set 1: 255/75
21801			7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21806			7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21812			7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21818	2903,1		7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21824			8,3	50	6	2	2	1	1	8,33	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21829			5,6	45	6	2	2	1	1	7,5	0,75	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21835			8,3	50	6	2	2	1	1	8,33	1	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
21840	14412		5,6	45	6	2	2	1	1	7,5	0,75	Nodular Limestone	1		set 1: 258/70 set 2: 178/90
76	27393	360,4													
21846	809,8		7,5	45	6	2	2	1	1	7,5	1	Claystone	2	clay filled fracture 255/ 70	set 1: 258/70 set 2: 178/90
21851			8,3	50	6	2	2	1	1	8,33	1	Claystone	2	calcite 178/90	set 1: 258/70 set 2: 178/90
21857			7,5	45	6	2	2	1	1	7,5	1	Claystone	2	"	set 1: 258/70 set 2: 178/90

21862	13140	18	3,8	45	6	2	4	1	1	7,5	0,5	Claystone	2	"	set 1: 255/60 set 2: 177/90
21868	739,4		1,9	45	6	2	6	1	1	7,5	0,25	Nodular Limestone	1		set 1: 255/60 set 2: 177/90
21873			2,8	45	6	2	4	1	1	7,5	0,38	Nodular Limestone	1		set 1: 255/60 set 2: 177/90
21878			5,0	45	6	2	3	1	1	7,5	0,67	Nodular Limestone	1		set 1: 255/60 set 2: 178/90 set 3: 215/60
32,5	14689	452,0													

21884	10048	52	3,8	45	6	2	4	1	1	7,5	0,5	Nodular Limestone	1	Fault 258/70 and 178/90	set 1: 255/60 set 2: 178/90 set 3: 215/60
21889	1656,7		1,8	45	6	2	6	1	1	7,5	0,33	Nodular Limestone	1		set 1: 255/60 set 2: 178/90 set 3: 215/60
21895			1,0	25	6	2	6	1	1	4,17	0,25	Nodular Limestone	1		set 1: 258/50
21901	9956,7	28										Nodular Limestone	1	Fault 5m wide 078/80 with clay zone	set 1: 078/80
17	21661	1274,2													

21902	936,4		1,9	45	6	2	6	1	1	7,5	0,25	Nodular Limestone	1		set 1: 256/70 set 2: 355/90
21908			1,9	45	6	2	6	1	1	7,5	0,25	Nodular Limestone	1		set 1: 256/70 set 2: 355/90
21917			3,1	55	6	2	6	1	1	9,17	0,33	Nodular Limestone	1		set 1: 256/70 set 2: 355/90
21919			4,6	55	6	2	4	1	1	9,17	0,5	Nodular Limestone	1		set 1: 256/70 set 2: 355/90
21923	18580	37	4,2	50	6	2	4	1	1	8,33	0,5	Nodular Limestone	1		set 1: 258/80 set 2: 350/80
21928	1338,5											Nodular Limestone	1		set 1: 258/80 set 2: 350/80
26	20855	802,1													

21930			5,0	60	6	2	3	1	1	10	0,5	Nodular Limestone	1	Fault 270/75	set 1: 258/80 set 2: 350/80
21936			1,7	60	9	1	4	1	1	6,67	0,25	Nodular Limestone	1	Fault 258/60	set 1: 258/80 set 2: 350/80
5,5															

21941			4,6	55	6	2	3	1	1	9,17	0,5	Claystone	2		set 1: 258/90 set 2: 350/90
21944	25065		4,6	55	6	2	3	1	1	9,17	0,5	Claystone	2		set 1: 258/90 set 2: 350/90
21950	4125,4	4,5	5,0	60	6	2	3	1	1	10	0,5	Claystone	2		set 1: 258/90 set 2: 350/90
21953			5,0	60	6	2	3	1	1	10	0,5	Claystone	2		set 1: 258/90 set 2: 350/90
21958			6,7	60	6	2	3	1	1	10	0,67	Claystone	2		set 1: 258/90 set 2: 350/90
21964	24773	74,5	4,2	50	6	2	3	1	1	8,33	0,5	Claystone	2		set 1: 258/90 set 2: 350/90
21969	8687,5	2	5,0	60	6	2	3	1	1	10	0,5	Claystone	2	fold axis	set 1: 258/90 set 2: 350/90
21974			3,6	65	9	2	3	1	1	7,22	0,5	Claystone	2		set 1: 075/60
33	62650	1898,5													
21980	930,2		2,5	60	9	2	4	1	1	6,67	0,38	Claystone	2	Fault 078/60	set 1: 075/60
21986	24192	132	5,4	65	6	2	3	1	1	10,8	0,5	Nodular Limestone	1	"	set 1: 075/60
21991	8925,6	10	2,5	60	9	2	4	1	1	6,67	0,38	Nodular Limestone	1	fold axis	set 1: 075/60
21997			3,8	60	6	2	4	1	1	10	0,38	Nodular Limestone	1	Fault layer ll	set 1: 255/75 set 2: 355/80
17	34048	2002,8													
22004	10176	360	2,2	60	9	2	3	1	1	6,67	0,5	Nodular Limestone	1		set 1: 255/75 set 2: 355/90
22010	2125,7	3	2,6	50	9	2	3	1	1	5,56	0,67	Claystone	2		set 1: 255/75 set 2: 355/90
6,5	12302	1892,6													
22018	3093,8		4,4	60	9	2	3	1	1	6,67	0,67	Claystone	2	Fault + diabase 2m 255/50	set 1: 255/50 set 2: 355/80
22021	20014	169	7,2	65	6	2	3	1	1	10,8	0,67	Claystone	2		set 1: 255/50 set 2: 355/80
3	23108	7702,5													
22021	20014	169	7,2	65	6	2	3	1	1	10,8	0,67	Claystone	2		set 1: 255/50 set 2: 355/80
22026	395,8		6,7	60	6	2	3	1	1	10	0,67	Claystone	2		set 1: 255/50 set 2: 355/80
22032			10,0	60	6	2	2	1	1	10	1	Claystone	2		set 1: 255/50 set 2: 355/80
11	20410	1855,4													
22037	14372	9	10,0	80	6	2	2	1	1	13,3	0,75	sandstone	4	Calcite coating	set 1: 255/50 set 2: 355/80

22044	370,6		10,6	85	6	2	2	1	1	14,2	0,75	sandstone	4		set 1: 255/50 set 2: 355/80
6,5	14742	2268,0													

22055			6,3	75	6	2	3	1	1	12,5	0,5	Limestone	3		set 1: 255/60 set 2: 355/90
22060	12261	1	4,7	75	6	2	4	1	1	12,5	0,38	Limestone	3		set 1: 255/60 set 2: 355/90
22066	540,9		6,3	75	6	2	3	1	1	12,5	0,5	Limestone	3		set 1: 255/60 set 2: 355/90
22071			6,3	75	6	2	3	1	1	12,5	0,5	Limestone	3		set 1: 255/60 set 2: 355/90
22076	9905,7		4,2	50	6	2	3	1	1	8,33	0,5	Limestone	3		set 1: 255/60 set 2: 355/90
22082	980,6		4,2	50	6	2	3	1	1	8,33	0,5	Limestone	3		set 1: 255/60 set 2: 355/90
22087			6,3	75	6	2	3	1	1	12,5	0,5	Limestone	3		set 1: 255/70
22093	17401	13,5	4,2	50	6	2	3	1	1	8,33	0,5	Limestone	3		set 1: 255/70
22098	540		5,4	65	6	2	3	1	1	10,8	0,5	Limestone	3		set 1: 255/70 set 2: 355/90 set 3: 255/30
22104			8,1	65	4	2	3	1	1	16,3	0,5	Limestone	3		set 1: 255/70 set 2: 355/90 set 3: 255/30
49	41628	849,6													

22104			8,1	65	4	2	3	1	1	16,3	0,5	Limestone	3		set 1: 255/70 set 2: 355/90 set 3: 255/30
22109	14224	7	5,0	60	6	2	4	1	1	10	0,5	Limestone	3	0,5cm fault 255/70	set 1: 255/70 set 2: 355/90 set 3: 255/30
5,5	14224	2586,2													

22115	695,7		5,0	60	6	2	4	1	1	10	0,5	Limestone	3		set 1: 255/70 set 2: 355/90
22120	17290	2	7,2	65	6	2	3	1	1	10,8	0,67	Limestone	3		set 1: 255/70 set 2: 355/90
22128	456		5,8	70	6	2	3	1	1	11,7	0,5	Nodular Limestone	1		set 1: 255/70 set 2: 355/90 set 3: 255/30
13	18442	1418,6													

22132			6,7	80	6	2	3	1	1	13,3	0,5	Nodular Limestone	1	Fault ll layer dip 70	set 1: 255/70 set 2: 355/90
22137	3861,9		11,3	90	6	2	2	1	1	15	0,75	Nodular Limestone	1		set 1: 255/70
5	3861,9	772,4													

22137	3861,9		11,3	90	6	2	2	1	1	15	0,75	Nodular Limestone	1		set 1: 255/70

22143	449,5		9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1		set 1: 255/70
22148			40,0	80	3	2	1	1	1	26,7	1,5	Nodular Limestone	1		set 1: 255/70
22154	12815		10,0	80	6	2	2	1	1	13,3	0,75	Nodular Limestone	1		set 1: 255/60 set 2: 355/90
22160	281,8		10,0	80	6	2	2	1	1	13,3	0,75	Nodular Limestone	1		set 1: 255/60 set 2: 355/90
22166			6,7	80	6	2	3	1	1	13,3	0,5	Nodular Limestone	1		set 1: 255/60 set 2: 355/90
22171			6,3	75	6	2	3	1	1	12,5	0,5	Nodular Limestone	1	clay filled fracture 255/50	set 1: 255/70
22175	7276	22,5										Nodular Limestone	1		set 1: 255/70
22181	354,7		10,0	80	6	2	2	1	1	13,3	0,75	Nodular Limestone	1		set 1: 255/70
22188			12,5	75	6	2	2	1	1	12,5	1	Nodular Limestone	1		set 1: 254/60
22191	10218	8										Nodular Limestone	1		set 1: 254/60
22195	5202,8	134	11,7	70	6	2	2	1	1	11,7	1	Nodular Limestone	1		set 1: 254/60
22197	369,8		13,3	80	6	2	2	1	1	13,3	1	Nodular Limestone	1		set 1: 254/60
22210			17,5	70	4	2	2	1	1	17,5	1	Nodular Limestone	1		set 1: 254/60 set 2: 355/90
22214			13,3	80	6	2	2	1	1	13,3	1	Nodular Limestone	1		set 1: 254/60 set 2: 355/90
22220	4845,5		12,5	75	6	2	2	1	1	12,5	1	Nodular Limestone	1		set 1: 255/60
22226	1390,6		9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1		set 1: 255/60
22231			8,8	70	6	2	2	1	1	11,7	0,75	Nodular Limestone	1		set 1: 255/60
22237			9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1		set 1: 255/80 set 2: 000/70
99,5	47066	473,0													

22242	23018	160	4,2	75	9	2	3	1	1	8,33	0,5	Nodular Limestone	1		set 1: 255/80 set 2: 000/70
22248	1565,9		5,8	70	9	2	2	1	1	7,78	0,75	Nodular Limestone	1		set 1: 255/80 set 2: 000/70

22253			5,8	70	9	2	2	1	1	7,78	0,75	Nodular Limestone	1	Fold II tunnel trace	set 1: 255/80 set 2: 000/70
22264	39954	71	5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1		set 1: 255/70 set 2: 030/90
22270	598,4											Not mapped			
22282			12,5	75	6	2	2	1	1	12,5	1	Nodular Limestone	1		
22287	35090	63										Not mapped			
45	100225	2227,2													
22293	459,6		5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1		set 1: 260/90 set 2: 355/70
22298			5,0	60	9	2	2	1	1	6,67	0,75	Nodular Limestone	1	clay filled fracture 260/90	set 1: 260/90 set 2: 355/70
22303			6,3	75	9	2	2	1	1	8,33	0,75	Nodular Limestone	1		set 1: 260/90 set 2: 355/70
22309	17780	28	8,8	70	6	2	2	1	1	11,7	0,75	Nodular Limestone	1		set 1: 260/90 set 2: 355/70
16,5	18240	1105,4													
22314	922,6		5,8	70	6	2	3	1	1	11,7	0,5	Nodular Limestone	1	Fault 078/80 folded layering? 260/30	set 1: 260/90
22320	31914	32,5	5,4	65	6	2	3	1	1	10,8	0,5	Nodular Limestone	1		set 1: 260/85
22325	570,3		6,3	75	9	2	2	1	1	8,33	0,75	Nodular Limestone	1		set 1: 078/83
22331			8,9	80	9	2	2	1	1	8,89	1	Nodular Limestone	1	diabase 002/70 clay zone follows ca 22360-22385	set 1: 078/83
22336			4,0	80	6	2	2	1	2,5	13,3	0,75	Nodular Limestone	1	" clay 078/85 reverse fault	set 1: 078/83
22342	13087		9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1	"	set 1: 260/80
22347			4,1	65	6	2	4	1	1	10,8	0,38	Nodular Limestone	1	"	set 1: 260/80
22348	215,3											Nodular Limestone	1	"	set 1: 260/80

22353			5,4	65	6	2	3	1	1	10,8	0,5	Nodular Limestone	1	" set 2 folded? Thrust fault 330/50	set 1: 255/85 set 2: 330/50
22358	19569	5	5,4	65	6	2	3	1	1	10,8	0,5	Nodular Limestone	1	"	set 1: 255/85 set 2: 330/50 set 3: 030/90
22365	351,3		3,6	65	9	2	3	1	1	7,22	0,5	Nodular Limestone	1	"	set 1: 255/85 set 2: 330/50 set 3: 030/90
22371			3,3	60	9	2	3	1	1	6,67	0,5	Nodular Limestone	1	"	set 1: 255/85 set 2: 330/50 set 3: 030/90
22377	18013	153	5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1	"	set 1: 255/85 set 2: 330/50 set 3: 030/90
22383	5169,7	8	5,0	60	9	2	2	1	1	6,67	0,75	Nodular Limestone	1	"	set 1: 255/85 set 2: 330/50 set 3: 030/90
22388			5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1	diabase stop in roof Fault 262/85	set 1: 260/70 set 2: 002/70
74	89812	1213,7													

22394	28469	110	5,4	65	9	2	2	1	1	7,22	0,75	Nodular Limestone	1		set 1: 260/70 set 2: 002/70
22399	3338,5	20,1	5,0	60	6	2	3	1	1	10	0,5	Nodular Limestone	1		set 1: 260/70 set 2: 002/70
22405			3,6	65	9	2	3	1	1	7,22	0,5	Nodular Limestone	1		set 1: 260/70 set 2: 002/70
11	31808	2891,6													

22411	46553	1112	5,4	65	6	2	3	1	1	10,8	0,5	Nodular Limestone	1	Fault ll layering	set 1: 255/70 set 2: 030/45
22405			3,6	65	9	2	3	1	1	7,22	0,5	Nodular Limestone	1		set 1: 260/70 set 2: 002/70
6	46553	7758,8													

22416	10788	105	3,3	60	9	2	3	1	1	6,67	0,5	Nodular Limestone	1		set 1: 255/70 set 2: 030/45
22422	26756		3,3	60	9	2	3	1	1	6,67	0,5	Nodular Limestone	1		set 1: 255/70 set 2: 030/45
22427	231,1		3,3	60	9	2	3	1	1	6,67	0,5	Nodular Limestone	1		set 1: 255/70 set 2: 002/90
22437	19790		3,6	65	9	2	3	1	1	7,22	0,5	Nodular Limestone	1		set 1: 255/70 set 2: 002/90
21	57565	2741,17143													

22442	419,6		2,8	50	9	2	3	1	1	5,56	0,5	Nodular Limestone	1	intrusive 270/60	set 1: 255/70 set 2: 002/90
22448			3,6	65	9	2	3	1	1	7,22	0,5	Nodular Limestone	1		set 1: 255/70 set 2: 002/90
6	419,6	69,9													

22448			3,6	65	9	2	3	1	1	7,22	0,5	Nodular Limestone	1		set 1: 255/70 set 2: 002/90
22454	12842		3,3	60	9	2	3	1	1	6,67	0,5	Limestone	3		set 1: 255/70 set 2: 002/90
22459	661,5											Limestone	3		set 1: 255/70 set 2: 002/90
22465			8,8	70	6	2	2	1	1	11,7	0,75	Limestone	3		set 1: 255/80 set 2: 170/70
22476			8,1	65	6	2	2	1	1	10,8	0,75	Limestone	3		set 1: 255/80 set 2: 170/70
28	13504	482,3													

22489	7010,2		3,1	55	9	2	3	1	1	6,11	0,5	Limestone	3	Fault 5 cm 020/50 from	set 1: 255/80 set 2: 170/70 set 3: 030/40
22495			3,3	60	9	2	3	1	1	6,67	0,5	Limestone	3	"	set 1: 255/80 set 2: 170/70 set 3: 030/40
22501			2,1	50	9	2	4	1	1	5,56	0,38	Limestone	3	"	set 1: 255/80 set 2: 170/70 set 3: 030/40
11,5	7010,2	609,6													

22506	12592		3,1	50	6	2	4	1	1	8,33	0,38	Limestone	3		set 1: 255/80 set 2: 170/90 set 3: 030/50
22511			7,5	60	6	2	2	1	1	10	0,75	Limestone	3		set 1: 255/80 set 2: 170/90 set 3: 030/50
22516			4,2	50	9	2	2	1	1	5,56	0,75	Limestone	3		set 1: 255/70
22522	12834	42	8,1	65	6	2	2	1	1	10,8	0,75	Limestone	3		set 1: 255/70 set 2: 180/60
16	25426	1589,1													

22528			12,5	75	6	2	2	1	1	12,5	1	Limestone	3	Trust fault ll layering	set 1: 255/70 set 2: 180/60
22533			4,2	75	9	2	3	1	1	8,33	0,5	Claystone	2	calcite swarm ll layer	set 1: 255/70 set 2: 180/60
5															

22533			4,2	75	9	2	3	1	1	8,33	0,5	Claystone	2	calcite swarm ll	set 1: 255/70 set 2: 180/60

														layer	
22537	12318											Claystone	2		set 1: 255/70
22544			9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 256/70 set 2: 300/85
22549			8,8	70	6	2	2	1	1	11,7	0,75	Claystone	2		set 1: 256/70 set 2: 300/85
22555	4654,1		8,1	65	6	2	2	1	1	10,8	0,75	Claystone	2		set 1: 256/70 set 2: 300/85
22560			9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 256/70 set 2: 300/85
26,5	16972	640,4													

22560			9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2		set 1: 256/70 set 2: 300/85
22565			7,5	60	6	2	2	1	1	10	0,75	Claystone	2	Fault 100/45	set 1: 256/70 set 2: 300/85
5,5															

22572	8158,9	4	11,3	60	4	2	2	1	1	15	0,75	Claystone	2		set 1: 256/80
22576			6,7	60	9	2	2	1	1	6,67	1	Claystone	2	calcite ll layer	set 1: 256/70
22583			9,2	55	6	2	2	1	1	9,17	1	Claystone	2		set 1: 256/70
22587	27928	13										Claystone	2		set 1: 256/70
15	36087	2405,8													

22593			7,5	60	6	2	2	1	1	10	0,75	Claystone	2	calcite vein 010/80 crushed rock and reverse structures 230/20	set 1: 256/70 set 2: 007/90 set 3: 230/20
22598			8,1	65	6	2	2	1	1	10,8	0,75	Nodular Limestone	1	" "	set 1: 256/70 set 2: 007/90 set 3: 230/20
22604	17190	106	7,5	60	6	2	2	1	1	10	0,75	Nodular Limestone	1	Trust fault structures	set 1: 256/70 set 2: 007/90
22609			7,2	65	6	2	3	1	1	10,8	0,67	Nodular Limestone	1	" "	set 1: 260/80 set 2: 187/80
16	17190	1074,4													

22615			8,1	65	6	2	2	1	1	10,8	0,75	Nodular Limestone	1		set 1: 260/80 set 2: 187/80
22620	18322	11,5	12,5	75	6	2	2	1	1	12,5	1	Nodular Limestone	1		set 1: 260/80 set 2: 187/80
22625			0,3	35	9	2	4	1	5	3,89	0,38	Nodular Limestone	1		set 1: 260/30 set 2: 052/75 set 3: 158/90

22626			8,8	70	6	2	2	1	1	11,7	0,75	Limestone	3		set 1: 260/80 set 2: 187/80
22628			0,33	30	9	2	3	1	5	3,33	0,5	Nodular Limestone	1		set 1: 260/30 set 2: 052/75 set 3: 158/90
22631			9,4	75	6	2	2	1	1	12,5	0,75	Limestone	3	clayfracture 260/80	set 1: 260/80 set 2: 187/80
22638	19547	14	8,3	75	6	2	3	1	1	12,5	0,67	Limestone	3		set 1: 260/80
22644			5,0	60	6	2	3	1	1	10	0,5	Limestone	3	folded calcite ll layering	set 1: 260/80 set 2: 195/60 set 3: 139/70
22649			4,4	40	6	2	3	1	1	6,67	0,67	Limestone	3		set 1: 253/80 set 2: 187/90
22655	26292	386	8,1	65	6	2	2	1	1	10,8	0,75	Limestone	3		set 1: 253/80 set 2: 012/85
22660			5,4	65	6	2	3	1	1	10,8	0,5	Limestone	3		set 1: 253/80 set 2: 012/85
22666			5,4	65	6	2	3	1	1	10,8	0,5	Limestone	3		set 1: 253/30 set 2: 012/85
22672	21228	48	5,8	70	6	2	3	1	1	11,7	0,5	Limestone	3		set 1: 253/30 set 2: 193/80
57	85389	1498,0													
22682			8,3	75	9	2	2	1	1	8,33	1	sandstone	4		set 1: 253/30 set 2: 193/80
22687	30397	56	3,9	70	9	2	3	1	1	7,78	0,5	sandstone	4	fold axis	set 1: 065/60 set 2: 013/65
5	30397	6079,4													
22695			5,8	70	6	2	4	1	1	11,7	0,5	Limestone	3		set 1: 065/60 set 2: 013/65
22703	40550	588										Limestone	3		set 1: 070/60 set 2: 013/65
22712			3,3	60	9	2	3	1	1	6,67	0,5	Limestone	3	intrusive 005/85 with 2-3m fault	set 1: 070/60 set 2: 005/65
22717			2,2	40	6	1	3	1	1	6,67	0,33	Limestone	3	Fault ll dike 078/85	set 1: 078/85 set 2: 005/85
22723	40098	572,7	2,8	50	9	2	3	1	1	5,56	0,5	Limestone	3	"	set 1: 078/85 set 2: 005/85 set 3: 123/30
27,5	80648	2932,7													
22728			5,8	70	6	2	3	1	1	11,7	0,5	Interbedded sandstone + limestone	4		set 1: 078/90 set 2: 005/75 set 3: 123/30
22734			6,3	75	6	2	3	1	1	12,5	0,5	Interbedded sandstone	4		set 1: 078/85 set 2: 005/85

												+ limestone			
22739	71077	1766,5	5,8	70	6	2	3	1	1	11,7	0,5	Interbedded sandstone + limestone	4		set 1: 078/90 set 2: 005/80
10,5	71077	6769,2													
22744			8,3	75	9	2	2	1	1	8,33	1	Interbedded sandstone + limestone	4	dike 000/85	set 1: 075/80 set 2: 000/20
22749			3,9	70	9	2	3	1	1	7,78	0,5	Interbedded sandstone + limestone	4	"	set 1: 260/80 set 2: 010/80
22755	34268	357	3,1	55	9	2	3	1	1	6,11	0,5	Interbedded sandstone + limestone	4	"	set 1: 260/80 set 2: 010/80
22761			5,8	70	6	2	3	1	1	11,7	0,5	Limestone	3	"	set 1: 080/70 set 2: 000/80
22767			8,8	70	6	2	2	1	1	11,7	0,75	Limestone	3	"	set 1: 080/70 set 2: 000/80
22772	56749	1285	8,1	65	6	2	2	1	1	10,8	0,75	Limestone	3	"	set 1: 080/70 set 2: 000/80
28,5	91017	3193,6													
22775			5,4	65	6	2	2	1	1	10,8	0,75	Limestone	3		set 1: 260/45 set 2: 010/80
22780			6,3	75	6	2	3	1	1	12,5	0,5	Limestone	3		set 1: 260/45 set 2: 010/80
5															
23540			2,5	50	4	2	2	1	5	12,5	1	Nodular Limestone	1		set 1: 092/30 set 2: 120/70 set 3: 350/80
23548			3,8	75	4	2	2	1	5	18,8	1	Nodular Limestone	1		set 1: 092/30 set 2: 120/70 set 3: 350/80
23551			3,5	70	4	2	2	1	5	17,5	1	Limestone	3		set 1: 213/10 set 2: 330/10 set 3: 017/85 set 4: 120/70
23557			3,5	75	4	2	2	1	5	18,8	1	Limestone	3		set 1: 213/10 set 2: 330/10 set 3:

															017/85 set 4: 120/70
23561	2717,9											Limestone	3		set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23561	4558,1											Limestone	3		set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23563			2,3	70	6	2	2	1	5	11,7	1	Limestone	3		set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23566			2,3	70	6	2	2	1	5	11,7	1	Limestone	3		set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23568			2,5	65	6	2	4	1	2,5	10,8	0,5	Limestone	3		set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23569	1707,6											Limestone	3		set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23569	3695,7		2,9	65	9	2	3	1	2,5	7,22	0,5	Limestone	3		set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23570			2,2	65	6	2	4	1	2,5	10,8	0,5	Limestone	3		set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23571			2,9	65	9	2	3	1	2,5	7,22	0,5	Limestone	3		set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
31	12679	409,0													
23575			1,3	65	9	2	3	1	2,5	7,22	0,5	Limestone	3	Fault 112/80	set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23578			1,5	65	9	2	3	1	2,5	7,22	0,67	Limestone	3		set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
3															
23578			1,5	65	9	2	3	1	2,5	7,22	0,67	Limestone	3	Synform ll tunnel trace	set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23578			1,8	70	9	2	3	1	2,5	7,78	0,67	Limestone	3		set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23580	6256,4											Limestone	3		set 1: 242/30 set 2: 195/85 set 3: 112/80
23580	556,9											Limestone	3		set 1: 242/30 set 2: 195/85 set 3: 112/80
23582			1,7	75	6	2	3	1	5	12,5	0,67	Limestone	3		set 1: 102/80 set 2: 195/85 set 3: 212/55
23591			2,5	75	6	2	2	1	5	12,5	1	Limestone	3		set 1: 102/80 set 2: 195/85 set 3: 212/55
23592	7657,5		1,5	60	6	2	2	1	5	10	0,75	Limestone	3		set 1: 102/80 set 2: 195/85 set 3: 212/55

23595			1,6	65	6	2	2	1	5	10,8	0,75	Limestone	3		set 1: 102/80 set 2: 195/85 set 3: 212/55
23595			0,8	75	6	1	3	1	5	12,5	0,33	Limestone	3		set 1: 102/80 set 2: 195/85 set 3: 212/55
23598			0,8	75	6	1	3	1	5	12,5	0,33	Limestone	3	fold axis	set 1: 278/90 set 2: 195/85 set 3: 150/85
23600			2,3	70	6	2	2	1	5	11,7	1	Limestone	3		set 1: 278/90 set 2: 060/75 set 3: 140/85
23600			1,4	85	9	2	2	1	5	9,44	0,75	Limestone	3		set 1: 278/90 set 2: 060/75 set 3: 140/85
23603	4584,7		1,2	70	9	2	2	1	5	7,78	0,75	Limestone	3		set 1: 278/45 set 2: 060/75 set 3: 140/80
23603	2272,6		2,6	80	6	2	2	1	5	13,3	1	Limestone	3		set 1: 278/90 set 2: 060/75 set 3: 140/85
23605			1,6	60	6	2	2	1	5	10	0,75	Limestone	3		set 1: 260/20 set 2: 052/75 set 3: 108/80
23605			1,1	65	9	2	2	1	5	7,22	0,75	Limestone	3		set 1: 260/45 set 2: 060/75 set 3: 108/80
23611			1	60	6	2	3	1	5	10	0,5	Limestone	3		set 1: 260/20 set 2: 052/75 set 3: 108/80
23613	1528,9											Limestone	3		set 1: 260/20 set 2: 052/75 set 3: 108/80
23613	5469		0,45	40	9	2	3	1	5	4,44	0,5	Limestone	3		set 1: 260/20 set 2: 052/75 set 3: 108/80
23616			0,4	35	9	2	3	1	5	3,89	0,5	Limestone	3	calcite ll layer	set 1: 260/20 set 2: 052/75 set 3: 108/80
23622	6945,6		0,2	30	9	1	3	1	5	3,33	0,33	Limestone	3		set 1: 260/30 set 2: 052/75 set 3: 158/90
23622	8311,6											Limestone	3		set 1: 260/30 set 2: 052/75 set 3: 158/90
23631	9561,2											Nodular Limestone	1		set 1: 260/30 set 2: 052/75 set 3: 158/90
23631	2562	18										Nodular Limestone	1		set 1: 260/30 set 2: 052/75 set 3: 158/90
23634			0,26	35	9	2	3	1	5	3,89	0,5	Nodular Limestone	1		set 1: 260/30 set 2: 052/75 set 3: 158/90
23640	10672														
23640	8429,4	6													
62	74808	1206,6													

Appendix D1
Non-faulted sections

Non-faulted sections

Chainage no	Grout take	Length of section	Grout pr. m tunnel	Q-value	RQD	Jn	Jr	Ja	Jw	SRF	RQD/Jn	Jr/Ja	Lithology		Strike/dip
19867	9016,2	7	1 288,0	5,8	70	6	1,5	3	1	1	11,6667	0,5	Nodular Limestone	1	set 1: 075/60 set 2: 163/70 set 3: 215/85
19874				4,4	80	6	1	3	1	1	13,3333	0,33	Nodular Limestone	1	set 1: 070/45 set 2: 163/70 set 3: 215/85
	9016,2														
19895				9,4	75	6	1,5	2	1	1	12,5	0,75	Claystone	2	set 1: 075/45 set 2: 359/85
19901	31966			9,4	75	6	1,5	2	1	1	12,5	0,75	Claystone	2	set 1: 075/45 set 2: 359/85
19906,5				9,4	75	6	1,5	2	1	1	12,5	0,75	Claystone	2	set 1: 075/30 set 2: 359/85
19911				14,1	75	4	1,5	2	1	1	18,75	0,75	Claystone	2	set 1: 075/30 set 2: 359/85
19917	19120			9,4	75	6	1,5	2	1	1	12,5	0,75	Claystone	2	set 1: 075/30 set 2: 359/85
19923		55	1940,0	8,8	70	6	1,5	2	1	1	11,6667	0,75	Claystone	2	set 1: 064/30 set 2: 100/85
19928,5				9,4	75	6	1,5	2	1	1	12,5	0,75	Claystone	2	set 1: 064/30 set 2: 100/85
19934	26294			8,8	70	6	1,5	2	1	1	11,6667	0,75	Claystone	2	set 1: 064/30 set 2: 100/85
19950	29322			4,7	75	6	1,5	4	1	1	12,5	0,38	Claystone	2	set 1: 250/05 set 2: 148/70
Sum	106702														
19984	27205			14,2	85	6	2	2	1	1	14,1667	1	Limestone	3	set 1: 250/05 set 2: 148/90
19989				13,3	80	6	2	2	1	1	13,3333	1	Limestone	3	set 1: 250/05 set 2: 148/80 set 3: 025/90
19994,5				13,3	80	6	2	2	1	1	13,3333	1	Limestone	3	set 1: 250/10 set 2: 148/80 set 3: 025/90
20000	30214												Limestone	3	set 1: 250/20 set 2: 070/70 set 3: 173/90
20005				15,0	80	4	1,5	2	1	1	20	0,75	Limestone	3	set 1: 250/20 set 2: 070/70 set 3: 320/90
20010,5				11,7	70	6	2	2	1	1	11,6667	1	Limestone	3	set 1: 250/20 set 2: 070/70 set 3: 173/90 set 4: 300/15
20017	16008			12,5	75	6	2	2	1	1	12,5	1	Limestone	3	set 1: 250/20 set 2: 070/70 set 3: 173/90 set 4: 300/15
20021,5				10,8	65	6	2	2	1	1	10,8333	1	Limestone	3	set 1: 250/40 set 2: 150/80 set 3: 205/45
20027				10,0	60	6	2	2	1	1	10	1	Claystone	2	set 1: 250/20 set 2: 150/80 set 3: 025/45 set 4: 205/45
20032	9474,2			11,7	70	6	2	2	1	1	11,6667	1	Claystone	2	set 1: 250/20 set 2: 207/10
20039				15,0	60	4	2	2	1	1	15	1	Claystone	2	set 1: 250/20 set 2: 329/90
20043,5		104	1303,7	15,0	60	4	2	2	1	1	15	1	Claystone	2	set 1: 250/20 set 2: 329/90
20048	8661,3			10,8	65	6	2	2	1	1	10,8333	1	Claystone	2	set 1: 250/20 set 2: 329/90
20060				8,3	75	6	2	3	1	1	12,5	0,67	Claystone	2	set 1: 250/30 set 2 :329/90
20065	19867												Claystone	2	set 1: 250/30 set 2 :329/90
20070,5				9,4	75	6	1,5	2	1	1	12,5	0,75	Claystone	2	set 1: 250/30 set 2 :329/90
20076,5				8,8	70	6	1,5	2	1	1	11,6667	0,75	Claystone	2	set 1: 250/30 set 2 :329/90

20081	24150			9,4	75	6	1,5	2	1	1	12,5	0,75	Limestone	3	set 1: 250/30 set 2 :329/90
20088				9,4	75	6	1,5	2	1	1	12,5	0,75	Limestone	3	set 1: 250/45 set 2: 320/90
Sum	135581														

20117				9,4	75	6	1,5	2	1	1	12,5	0,75	Limestone	3	set 1: 254/50 set 2: 350/90
20122,5				8,8	70	6	1,5	2	1	1	11,6667	0,75	Limestone	3	set 1: 254/50 set 2: 350/90
20130	17040	40	1099,5	8,8	70	6	1,5	2	1	1	11,6667	0,75	Limestone	3	set 1: 254/50 set 2: 350/90
20145,5	26942			8,8	70	6	1,5	2	1	1	11,6667	0,75	Limestone	3	set 1: 254/50 set 2: 350/90
20151,5				5,8	70	6	1,5	3	1	1	11,6667	0,5	Limestone	3	set 1: 254/50 set 2: 350/90
20157				5,8	70	6	1,5	3	1	1	11,6667	0,5	Limestone	3	set 1: 254/50 set 2: 008/80
Sum	43982														

20168				4,2	75	9	1,5	3	1	1	8,33333	0,5	Limestone	3	set 1: 258/50 set 2: 190/90 set 3: 008/30
20173	350			4,2	75	9	1,5	3	1	1	8,33333	0,5	Limestone	3	set 1: 258/50 set 2: 190/90 set 3: 008/30
20178	36436	22	1693	9,4	75	6	1,5	2	1	1	12,5	0,75	Nodular Limestone	1	set 1: 258/50 set 2: 190/90 set 3: 008/30 set 4: 248/70
20184,5				9,4	75	6	1,5	2	1	1	12,5	0,75	Nodular Limestone	1	set 1: 258/60 set 2: 190/50
20190	460			11,7	70	6	2	2	1	1	11,6667	1	Nodular Limestone	1	set 1: 258/60 set 2: 190/50
Sum	37246														

20239	1459,4			5,8	70	6	1,5	3	1	1	11,6667	0,5	Nodular Limestone	1	set 1: 254/70
20245		6	243,2	6,3	75	6	1,5	3	1	1	12,5	0,5	Nodular Limestone	1	set 1: 254/70
Sum	1459,4														

20256	640			3,9	70	9	1,5	3	1	1	7,77778	0,5	Nodular Limestone	1	set 1: 254/70
20262	12916			6,3	75	6	1,5	3	1	1	12,5	0,5	Nodular Limestone	1	set 1: 254/70
20267,5				6,3	75	6	1,5	3	1	1	12,5	0,5	Nodular Limestone	1	set 1: 254/70
20274	369,3	34	794,7	5,8	70	6	1,5	3	1	1	11,6667	0,5	Nodular Limestone	1	set 1: 254/70
20280	12715												Nodular Limestone	1	set 1: 254/70
20284				6,3	75	6	1,5	3	1	1	12,5	0,5	Nodular Limestone	1	set 1: 254/70
20290	381,1			5,8	70	6	1,5	3	1	1	11,6667	0,5	Nodular Limestone	1	set 1 :255/60 set 2: 120/90
Sum	27021														

20389	633,8			3,3	60	9	1,5	3	1	1	6,66667	0,5	Limestone	3	set 1: 083/70
20394,5	7077,3												Limestone	3	set 1: 083/70
20405	666			4,6	55	6	1,5	3	1	1	9,16667	0,5	Limestone	3	set 1: 083/70
20411	10940	39,5	524,3	5,0	60	6	1,5	3	1	1	10	0,5	Limestone	3	set 1: 083/70
20418	257			5,4	65	6	1,5	3	1	1	10,8333	0,5	Limestone	3	set 1: 083/70
20423				7,5	60	6	1,5	2	1	1	10	0,75	Limestone	3	set 1: 083/70
20428,5	1133,6			4,6	55	6	1,5	3	1	1	9,16667	0,5	Limestone	3	set 1: 083/70

Sum 20708

20512	14765			3,9	70	9	1,5	3	1	1	7,77778	0,5	Limestone	3	set 1: 250/30 set 2: 176/85
20518				5,8	70	6	1,5	3	1	1	11,6667	0,5	Limestone	3	set 1: 250/30 set 2: 176/85
20524				6,3	75	6	1,5	3	1	1	12,5	0,5	Limestone	3	set 1: 250/30 set 2: 130/90
20529	4608			6,3	75	6	1,5	3	1	1	12,5	0,5	Limestone	3	set 1: 250/30 set 2: 130/90
20535	25136			8,1	65	6	1,5	2	1	1	10,8333	0,75	Limestone	3	set 1: 250/30 set 2: 130/90
20541				6,9	55	6	1,5	2	1	1	9,16667	0,75	Limestone	3	set 1: 250/30 set 2: 130/90
20546,5				7,5	60	6	1,5	2	1	1	10	0,75	Limestone	3	set 1: 250/30 set 2: 130/90
20550,5	765,3												Limestone	3	set 1: 250/30 set 2: 130/90
20552				8,1	65	4	1,5	3	1	1	16,25	0,5	Limestone	3	set 1: 250/30 set 2: 130/90
20556	10671	78	1093,9	5,0	60	6	1,5	3	1	1	10	0,5	Limestone	3	set 1: 250/30 set 2: 130/90
20563				8,8	70	6	1,5	2	1	1	11,6667	0,75	Limestone	3	set 1: 255/30 set 2: 120/85
20568,5				9,4	75	6	1,5	2	1	1	12,5	0,75	Limestone	3	set 1: 255/30 set 2: 120/85
20573	585,9			5,0	60	6	1,5	3	1	1	10	0,5	Limestone	3	set 1: 255/30 set 2: 120/85
20579	15321			9,4	75	6	1,5	2	1	1	12,5	0,75	Limestone	3	set 1: 255/30 set 2: 120/85
20585				5,8	70	6	1,5	3	1	1	11,6667	0,5	Limestone	3	set 1: 255/30 set 2: 120/85
20590,5				7,1	85	6	1,5	3	1	1	14,1667	0,5	Limestone	3	set 1: 255/30 set 2: 355/75-90
20595	1458			5,0	60	6	1,5	3	1	1	10	0,5	Limestone	3	set 1: 255/30 set 2: 355/75-90
20601,5	12016			3,8	60	6	1,5	4	1	1	10	0,38	Limestone	3	set 1: 255/30 set 2: 355/75-90
20607				3,1	50	6	1,5	4	1	1	8,33333	0,38	Limestone	3	set 1: 255/30 set 2: 355/75-90

Sum 85327

20629				3,1	55	9	1,5	3	1	1	6,11111	0,5	Nodular Limestone	1	set 1: 255/30
20634		11	175,0	2,5	45	9	1,5	3	1	1	5	0,5	Nodular Limestone	1	set 1: 255/30
20640	1924,6			2,5	45	9	1,5	3	1	1	5	0,5	Nodular Limestone	1	set 1: 255/30

Sum 1924,6

20713				7,8	70	6	2	3	1	1	11,6667	0,67	Limestone	3	set 1: 255/75 set 2: 355/90

20718,5				6,7	60	6	2	3	1	1	10	0,67	Limestone	3	set 1: 255/75 set 2: 355/90
20722	7094,5												Limestone	3	set 1: 255/75 set 2: 355/90
20724				8,9	80	6	2	3	1	1	13,3333	0,67	Limestone	3	set 1: 260/60 set 2: 200/90 set 3: 330/90
20729,5				10,0	60	6	2	2	1	1	10	1	Nodular Limestone	1	set 1: 260/60 set 2: 200/90 set 3: 330/90
20735	10288	50	436,8	9,2	55	6	2	2	1	1	9,16667	1	Nodular Limestone	1	set 1: 260/60 set 2: 200/90 set 3: 330/90
20740				10,8	65	6	2	2	1	1	10,8333	1	Nodular Limestone	1	set 1: 260/60 set 2: 200/90 set 3: 330/90
20746				6,7	60	6	2	3	1	1	10	0,67	Nodular Limestone	1	set 1: 260/70
20753	406,3			5,6	50	6	2	3	1	1	8,33333	0,67	Nodular Limestone	1	set 1: 260/70 set 2: 034/10
20756	4053,2												Nodular Limestone	1	set 1: 260/70 set 2: 034/10
20757,5				6,1	55	6	2	3	1	1	9,16667	0,67	Nodular Limestone	1	set 1: 260/70 set 2: 034/10
20763				6,7	60	6	2	3	1	1	10	0,67	Nodular Limestone	1	set 1: 260/70 set 2: 034/10 set 3: 350/?
Sum	21842														

20775	8827,4			6,7	60	6	2	3	1	1	10	0,67	Nodular Limestone	1	set 1: 260/80 set 2: 034/10
20779,5		11	957,2	6,7	60	6	2	3	1	1	10	0,67	Nodular Limestone	1	set 1: 260/80 set 2: 106/90
20786	1702,2			5,6	50	6	2	3	1	1	8,33333	0,67	Claystone	2	set 1: 260/80 set 2: 034/10
Sum	10530														

20812	18032			4,4	40	6	2	3	1	1	6,66667	0,67	Claystone	2	set 1: 260/60 set 2: 350/80 set 3: 118/60
20818				5,0	45	6	2	3	1	1	7,5	0,67	Nodular Limestone	1	set 1: 260/60
20824	454,6			5,0	45	6	2	3	1	1	7,5	0,67	Nodular Limestone	1	set 1: 260/50
20829,5	15580	39	1179,7	5,0	45	6	2	3	1	1	7,5	0,67	Nodular Limestone	1	set 1: 260/50
20834,5				3,3	45	9	2	3	1	1	5	0,67	Nodular Limestone	1	set 1: 260/50 set 2: 350/90
20840				3,7	50	9	2	3	1	1	5,55556	0,67	Nodular Limestone	1	set 1: 260/50 set 2: 350/90
20845,5				3,7	50	9	2	3	1	1	5,55556	0,67	Nodular Limestone	1	set 1: 260/60
20851	11940			3,3	45	9	2	3	1	1	5	0,67	Nodular Limestone	1	set 1: 260/60
Sum	46007	Inbetween faults													

20977				5,0	30	6	2	2	1	1	5	1	Nodular Limestone	1	set 1: 248/80 set 2: 350/80

20982				6,7	40	6	2	2	1	1	6,66667	1	Nodular Limestone	1	set 1: 248/80 set 2: 350/80
20987				6,7	40	6	2	2	1	1	6,66667	1	Nodular Limestone	1	set 1: 248/80 set 2: 350/80
20993	1045,8			7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1	set 1: 248/80 set 2: 350/80
20998				10,0	60	6	2	2	1	1	10	1	Nodular Limestone	1	set 1: 258/70 set 2: 178/90
Sum	1045,8														

21764				10,0	60	6	2	2	1	1	10	1	Nodular Limestone	1	set 1: 258/70 set 2: 178/90
21770				8,3	50	6	2	2	1	1	8,33333	1	Nodular Limestone	1	set 1: 258/70 set 2: 178/90
21775	7798,5			6,7	60	6	2	3	1	1	10	0,67	Nodular Limestone	1	set 1: 255/75
21781				9,2	55	6	2	2	1	1	9,16667	1	Nodular Limestone	1	set 1: 255/75
21786				9,2	55	6	2	2	1	1	9,16667	1	Nodular Limestone	1	set 1: 255/75
21791				9,2	55	6	2	2	1	1	9,16667	1	Nodular Limestone	1	set 1: 255/75
21795,5	2279,4			9,2	55	6	2	2	1	1	9,16667	1	Nodular Limestone	1	set 1: 255/75
21801		76	360,4	7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1	set 1: 258/70 set 2: 178/90
21806				7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1	set 1: 258/70 set 2: 178/90
21812				7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1	set 1: 258/70 set 2: 178/90
21818	2903,1			7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1	set 1: 258/70 set 2: 178/90
21823,5				8,3	50	6	2	2	1	1	8,33333	1	Nodular Limestone	1	set 1: 258/70 set 2: 178/90
21829				5,6	45	6	1,5	2	1	1	7,5	0,75	Nodular Limestone	1	set 1: 258/70 set 2: 178/90
21834,5				8,3	50	6	2	2	1	1	8,33333	1	Nodular Limestone	1	set 1: 258/70 set 2: 178/90
21840	14412			5,6	45	6	1,5	2	1	1	7,5	0,75	Nodular Limestone	1	set 1: 258/70 set 2: 178/90
Sum	27393														

21845,5	809,8			7,5	45	6	2	2	1	1	7,5	1	Claystone	2	set 1: 258/70 set 2: 178/90
21851				8,3	50	6	2	2	1	1	8,33333	1	Claystone	2	set 1: 258/70 set 2: 178/90
21857				7,5	45	6	2	2	1	1	7,5	1	Claystone	2	set 1: 258/70 set 2: 178/90
21862	13140	32,5	452,0	3,8	45	6	2	4	1	1	7,5	0,5	Claystone	2	set 1: 255/60 set 2: 177/90
21867,5	739,4			1,9	45	6	1,5	6	1	1	7,5	0,25	Nodular Limestone	1	set 1: 255/60 set 2: 177/90
21873				2,8	45	6	1,5	4	1	1	7,5	0,38	Nodular Limestone	1	set 1: 255/60 set 2: 177/90

21878				5,0	45	6	2	3	1	1	7,5	0,67	Nodular Limestone	1	set 1: 255/60 set 2: 178/90 set 3: 215/60
Sum	14689														
21902	936,4			1,9	45	6	1,5	6	1	1	7,5	0,25	Nodular Limestone	1	set 1: 256/70 set 2: 355/90
21907,5				1,9	45	6	1,5	6	1	1	7,5	0,25	Nodular Limestone	1	set 1: 256/70 set 2: 355/90
21917				3,1	55	6	2	6	1	1	9,16667	0,33	Nodular Limestone	1	set 1: 256/70 set 2: 355/90
21919		26	802,1	4,6	55	6	2	4	1	1	9,16667	0,5	Nodular Limestone	1	set 1: 256/70 set 2: 355/90
21922,5	18580			4,2	50	6	2	4	1	1	8,33333	0,5	Nodular Limestone	1	set 1: 258/80 set 2: 350/80
21928	1338,5												Nodular Limestone	1	set 1: 258/80 set 2: 350/80
Sum	20855														
22003,5	10176			2,2	60	9	1,5	3	1	1	6,66667	0,5	Nodular Limestone	1	set 1: 255/75 set 2: 355/90
22010	2125,7	6,5	1892,6	2,6	50	9	2	3	1	1	5,55556	0,67	Claystone	2	set 1: 255/75 set 2: 355/90
Sum	12302	Close to dike													
22021	20014			7,2	65	6	2	3	1	1	10,8333	0,67	Claystone	2	set 1: 255/50 set 2: 355/80
22026	395,8	11	1855,4	6,7	60	6	2	3	1	1	10	0,67	Claystone	2	set 1: 255/50 set 2: 355/80
22032				10,0	60	6	2	2	1	1	10	1	Claystone	2	set 1: 255/50 set 2: 355/80
Sum	20410	Close to dike													
22037	14372			10,0	80	6	1,5	2	1	1	13,3333	0,75	sandstone	4	set 1: 255/50 set 2: 355/80
22043,5	370,6	6,5	2268,0	10,6	85	6	1,5	2	1	1	14,1667	0,75	sandstone	4	set 1: 255/50 set 2: 355/80
Sum	14742														
22054,5				6,3	75	6	1,5	3	1	1	12,5	0,5	Limestone	3	set 1: 255/60 set 2: 355/90
22060	12261			4,7	75	6	1,5	4	1	1	12,5	0,38	Limestone	3	set 1: 255/60 set 2: 355/90
22065,5	540,9			6,3	75	6	1,5	3	1	1	12,5	0,5	Limestone	3	set 1: 255/60 set 2: 355/90
22071				6,3	75	6	1,5	3	1	1	12,5	0,5	Limestone	3	set 1: 255/60 set 2: 355/90
22076	9905,7	49	849,6	4,2	50	6	1,5	3	1	1	8,33333	0,5	Limestone	3	set 1: 255/60 set 2: 355/90
22081,5	980,6			4,2	50	6	1,5	3	1	1	8,33333	0,5	Limestone	3	set 1: 255/60 set 2: 355/90
22087				6,3	75	6	1,5	3	1	1	12,5	0,5	Limestone	3	set 1: 255/70

22092,5	17401			4,2	50	6	1,5	3	1	1	8,33333	0,5	Limestone	3	set 1: 255/70
22098	540			5,4	65	6	1,5	3	1	1	10,8333	0,5	Limestone	3	set 1: 255/70 set 2: 355/90 set 3: 255/30
22103,5				8,1	65	4	1,5	3	1	1	16,25	0,5	Limestone	3	set 1: 255/70 set 2: 355/90 set 3: 255/30
Sum	41628														

22115	695,7			5,0	60	6	2	4	1	1	10	0,5	Limestone	3	set 1: 255/70 set 2: 355/90
22120	17290	13	1418,6	7,2	65	6	2	3	1	1	10,8333	0,67	Limestone	3	set 1: 255/70 set 2: 355/90
22128	456			5,8	70	6	1,5	3	1	1	11,6667	0,5	Nodular Limestone	1	set 1: 255/70 set 2: 355/90 set 3: 255/30
Sum	18442														

22137	3861,9			11,3	90	6	1,5	2	1	1	15	0,75	Nodular Limestone	1	set 1: 255/70
22143	449,5			9,4	75	6	1,5	2	1	1	12,5	0,75	Nodular Limestone	1	set 1: 255/70
22148				40,0	80	3	1,5	1	1	1	26,6667	1,5	Nodular Limestone	1	set 1: 255/70
22154	12815			10,0	80	6	1,5	2	1	1	13,3333	0,75	Nodular Limestone	1	set 1: 255/60 set 2: 355/90
22160	281,8			10,0	80	6	1,5	2	1	1	13,3333	0,75	Nodular Limestone	1	set 1: 255/60 set 2: 355/90
22165,5				6,7	80	6	1,5	3	1	1	13,3333	0,5	Nodular Limestone	1	set 1: 255/60 set 2: 355/90
22171		99,5	473,0	6,3	75	6	1,5	3	1	1	12,5	0,5	Nodular Limestone	1	set 1: 255/70
22175	7276												Nodular Limestone	1	set 1: 255/70
22180,5	354,7			10,0	80	6	1,5	2	1	1	13,3333	0,75	Nodular Limestone	1	set 1: 255/70
22187,5				12,5	75	6	2	2	1	1	12,5	1	Nodular Limestone	1	set 1: 254/60
22191	10218												Nodular Limestone	1	set 1: 254/60
22195	5202,8			11,7	70	6	2	2	1	1	11,6667	1	Nodular Limestone	1	set 1: 254/60
22196,5	369,8			13,3	80	6	2	2	1	1	13,3333	1	Nodular Limestone	1	set 1: 254/60
22209,5				17,5	70	4	2	2	1	1	17,5	1	Nodular Limestone	1	set 1: 254/60 set 2: 355/90
22214				13,3	80	6	2	2	1	1	13,3333	1	Nodular Limestone	1	set 1: 254/60 set 2: 355/90
22220	4845,5			12,5	75	6	2	2	1	1	12,5	1	Nodular Limestone	1	set 1: 255/60
22225,5	1390,6			9,4	75	6	1,5	2	1	1	12,5	0,75	Nodular Limestone	1	set 1: 255/60
22231				8,8	70	6	1,5	2	1	1	11,6667	0,75	Nodular Limestone	1	set 1: 255/60
22236,5				9,4	75	6	1,5	2	1	1	12,5	0,75	Nodular Limestone	1	set 1: 255/80 set 2: 000/70
Sum	47066														

22572	8158,9			11,3	60	4	1,5	2	1	1	15	0,75	Claystone	2	set 1: 256/80
22576		15	2405,8	6,7	60	9	2	2	1	1	6,66667	1	Claystone	2	set 1: 256/70
22583				9,2	55	6	2	2	1	1	9,16667	1	Claystone	2	set 1: 256/70
22587	27928												Claystone	2	set 1: 256/70
Sum	36087	Thrust 22604													

22614,5				8,1	65	6	1,5	2	1	1	10,8333	0,75	Nodular Limestone	1	set 1: 260/80 set 2: 187/80
22620	18322			12,5	75	6	2	2	1	1	12,5	1	Nodular Limestone	1	set 1: 260/80 set 2: 187/80
22625				0,3	35	9	1,5	4	1	5	3,88889	0,38	Nodular Limestone	1	set 1: 260/30 set 2: 052/75 set 3: 158/90
22625,5				8,8	70	6	1,5	2	1	1	11,6667	0,75	Limestone	3	set 1: 260/80 set 2: 187/80
22628				0,33	30	9	1,5	3	1	5	3,33333	0,5	Nodular Limestone	1	set 1: 260/30 set 2: 052/75 set 3: 158/90
22631		57	1498,0	9,4	75	6	1,5	2	1	1	12,5	0,75	Limestone	3	set 1: 260/80 set 2: 187/80
22638	19547			8,3	75	6	2	3	1	1	12,5	0,67	Limestone	3	set 1: 260/80
22644				5,0	60	6	1,5	3	1	1	10	0,5	Limestone	3	set 1: 260/80 set 2: 195/60 set 3: 139/70
22649				4,4	40	6	2	3	1	1	6,66667	0,67	Limestone	3	set 1: 253/80 set 2: 187/90
22655	26292			8,1	65	6	1,5	2	1	1	10,8333	0,75	Limestone	3	set 1: 253/80 set 2: 012/85
22660				5,4	65	6	1,5	3	1	1	10,8333	0,5	Limestone	3	set 1: 253/80 set 2: 012/85
22666				5,4	65	6	1,5	3	1	1	10,8333	0,5	Limestone	3	set 1: 253/30 set 2: 012/85
22671,5	21228			5,8	70	6	1,5	3	1	1	11,6667	0,5	Limestone	3	set 1: 253/30 set 2: 193/80
Sum	85389														

23540				2,5	50	4	2	2	1	5	12,5	1	Nodular Limestone	1	set 1: 092/30 set 2: 120/70 set 3: 35 0/80
23548				3,8	75	4	2	2	1	5	18,75	1	Nodular Limestone	1	set 1: 092/30 set 2: 120/70 set 3: 350/80
23551				3,5	70	4	2	2	1	5	17,5	1	Limestone	3	set 1: 213/10 set 2: 330/10 set 3: 017/85 set 4: 120/70
23557				3,5	75	4	2	2	1	5	18,75	1	Limestone	3	set 1: 213/10 set 2: 330/10 set 3: 017/85 set 4: 120/70
23561	2717,9												Limestone	3	set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23561	4558,1	31	409,0										Limestone	3	set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23563				2,3	70	6	2	2	1	5	11,6667	1	Limestone	3	set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23566				2,3	70	6	2	2	1	5	11,6667	1	Limestone	3	set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23568				2,5	65	6	2	4	1	2,5	10,8333	0,5	Limestone	3	set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23569	1707,6												Limestone	3	set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23569	3695,7			2,9	65	9	1,5	3	1	2,5	7,22222	0,5	Limestone	3	set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23570				2,2	65	6	2	4	1	2,5	10,8333	0,5	Limestone	3	set 1: 253/10 set 2: 297/10 set 3: 017/85 set 4: 120/80
23571				2,9	65	9	1,5	3	1	2,5	7,22222	0,5	Limestone	3	set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80

Sum	12679

Appendix D2
Faulted sections

Faulted sections

Chainage no	Grout take	Length of section	Grout pr. m tunnel	Q-value	RQD	Jn	Jr	Ja	Jw	SRF	RQD/Jn	Jr/Ja	Lithology		Comment	Strike/dip
19960				18,8	75	4	2	2	1	1	18,75	1	Limestone	3	" 30 cm clay zone 167/80 Fault!	set 1: 250/05 set 2: 148/70
19966	28003			6,3	75	6	2	4	1	1	12,5	0,5	Limestone	3	"	set 1: 250/05 set 2: 148/90
19972		18	1555,7	12,5	75	6	2	2	1	1	12,5	1	Limestone	3	clay filled fractures/fault 167/ 80 30cm wide	set 1: 250/05 set 2: 148/90 set 3: 030/90
19978				9,4	75	6	2	2	1	1	12,5	0,75	Limestone	3		set 1: 250/05 set 2: 148/90
Sum	28003															
20094				4,4	70	6	2	4	1	1	11,6667	0,38	Limestone	3	Fault layer ll	set 1: 250/45
20097	10898												Limestone	3	"	set 1: 250/45
20100,5		18	1385,1	4,4	70	6	2	4	1	1	11,6667	0,38	Limestone	3	"	set 1: 254/50 set 2: 350/90
20106,5				9,4	75	6	2	2	1	1	12,5	0,75	Limestone	3	Fault ll layer dip 45	set 1: 254/50 set 2: 000/80 set 3: 032/60
20112	14034			5,8	70	6	2	3	1	1	11,6667	0,5	Limestone	3		set 1: 254/50 set 2: 350/90
Sum	24932															
20301,5		5	171,8	5,4	65	9	2	2	1	1	7,22222	0,75	Nodular Limestone	1		set 1 :255/60 set 2: 120/90
20306,5	859,1			9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1	Fault 255/60	set 1: 255/60
Sum	859,1															
20377	10475	6,5	1611,5	5,4	65	9	2	2	1	1	7,22222	0,75	Limestone	3	" Fault 083/50	set 1: 083/70

20383,5				5,4	65	9	2	2	1	1	7,22222	0,75	Limestone	3	dike 335/90 0,2m	set 1: 083/70

Sum 10475

20645,5	19644												Nodular Limestone	1		set 1: 255/75 set 2: 355/90
20649				10,0	80	6	2	2	1	1	13,3333	0,75	Nodular Limestone	1		set 1: 255/75 set 2: 355/90
20655		21,5	1527,7	6,7	80	6	2	3	1	1	13,3333	0,5	Nodular Limestone	1		set 1: 255/75 set 2: 355/90
20661	3077,5			4,7	75	6	2	4	1	1	12,5	0,38	Nodular Limestone	1		set 1: 255/75 set 2: 355/90
20667	10124			5,4	65	6	2	3	1	1	10,8333	0,5	Nodular Limestone	1		set 1: 255/75 set 2: 355/90

Sum 32846 Fault at 20643

20673				3,8	60	6	2	4	1	1	10	0,38	Limestone	3		set 1: 255/75 set 2: 355/90
20678				5,4	65	6	2	3	1	1	10,8333	0,5	Limestone	3	clay filled fractures 300/50	set 1: 255/75 set 2: 355/90
20684		33,5	89,5	5,4	65	6	2	3	1	1	10,8333	0,5	Limestone	3	calcite ll layering	set 1: 255/75 set 2: 355/90
20689,5	2998						2		1	1			Limestone	3		set 1: 255/75 set 2: 355/90
20695,5				8,1	65	6	2	2	1	1	10,8333	0,75	Limestone	3		set 1: 255/75 set 2: 355/90
20701				7,8	70	6	2	3	1	1	11,6667	0,67	Limestone	3	Fault ll layerdeling	set 1: 255/75 set 2: 355/90
20706,5				5,0	60	6	2	3	1	1	10	0,5	Limestone	3	Fault ll set 1 0,2m	set 1: 255/75 set 2: 355/90

Sum 2998

20856,5				2,8	50	9	2	3	1	1	5,55556	0,5	Nodular Limestone	1	fault layer ll	set 1: 260/60 set 2: 170/80
20862				5,6	50	9	2	2	1	1	5,55556	1	Nodular Limestone	1		set 1 :255/70 set 2: 170/80
20867				4,2	50	9	2	2	1	1	5,55556	0,75	Nodular Limestone	1		set 1 :255/70 set 2: 170/80

20873	2584,5	49,5	296,4	5,6	50	9	2	2	1	1	5,55556	1	Nodular Limestone	1		set 1 :255/70 set 2: 170/80
20879				8,3	50	6	2	2	1	1	8,33333	1	Nodular Limestone	1	Fault! 075/50	set 1 :255/70 set 2: 170/80
20884,5				9,2	55	6	2	2	1	1	9,16667	1	Nodular Limestone	1	Fault! 082/50	set 1 :255/70 set 2: 170/80
20890	6837,8												Nodular Limestone	1		set 1 :255/70 set 2: 170/80
20901				6,1	55	6	2	3	1	1	9,16667	0,67	Nodular Limestone	1	calcite ll set 2	set 1 :255/70 set 2: 170/80
20906	5248,9			6,1	55	6	2	3	1	1	9,16667	0,67	Nodular Limestone	1	Fault 170/85 ll tunnel trace	set 1: 254/70
Sum	14671															

20911	7183,2			5,6	50	6	2	3	1	1	8,33333	0,67	Nodular Limestone	1	clay filled fractures/fault 255/60	set 1: 254/70
20918				8,3	50	6	2	2	1	1	8,33333	1	Nodular Limestone	1		set 1: 254/70
20925	445	22	604,2	7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1		set 1: 255/70 set 2: 149/30
20928				7,5	45	6	2	2	1	1	7,5	1	Nodular Limestone	1		set 1: 255/70 set 2: 149/30
20933	5665													1	clay filled fractures layer ll l	set 1: 255/70 set 2: 149/30 set 3: 255/30
Sum	13293															

21884	10048			3,8	45	6	2	4	1	1	7,5	0,5	Nodular Limestone	1	Fault 258/70 and 178/90	set 1: 255/60 set 2: 178/90 set 3: 215/60
21889	1656,7	17	1274,2	1,8	45	6	2	6	1	1	7,5	0,33	Nodular Limestone	1		set 1: 255/60 set 2: 178/90 set 3: 215/60
21895				1,0	25	6	2	6	1	1	4,16667	0,25	Nodular Limestone	1		set 1: 258/50
21901	9956,7												Nodular Limestone	1	Fault 5m wide 078/80 with clay zone	set 1: 078/80
Sum	21661															

22103,5		5,5	2586,2	8,1	65	4	2	3	1	1	16,25	0,5	Limestone	3		set 1: 255/70 set 2: 355/90 set 3: 255/30
22109	14224			5,0	60	6	2	4	1	1	10	0,5	Limestone	3	0,5cm fault 255/70	set 1: 255/70 set 2: 355/90 set 3: 255/30

Sum 14224

22132		5	772,4	6,7	80	6	2	3	1	1	13,3333	0,5	Nodular Limestone	1	Fault ll layer dip 70	set 1: 255/70 set 2: 355/90
22137	3861,9			11,3	90	6	2	2	1	1	15	0,75	Nodular Limestone	1		set 1: 255/70

Sum 3861,9

22314	922,6			5,8	70	6	2	3	1	1	11,6667	0,5	Nodular Limestone	1	Fault 078/80 folded layering? 260/30	set 1: 260/90
22320	31914			5,4	65	6	2	3	1	1	10,8333	0,5	Nodular Limestone	1		set 1: 260/85
22325	570,3			6,3	75	9	2	2	1	1	8,33333	0,75	Nodular Limestone	1		set 1: 078/83
22330,5				8,9	80	9	2	2	1	1	8,88889	1	Nodular Limestone	1	diabase 002/70 clay zone ca 22360-22385	set 1: 078/83
22336				4,0	80	6	2	2	1	2,5	13,3333	0,75	Nodular Limestone	1	" clay 078/85 reverse fault	set 1: 078/83
22342	13087	74	1213,7	9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1	"	set 1: 260/80
22347				4,1	65	6	2	4	1	1	10,8333	0,38	Nodular Limestone	1	"	set 1: 260/80
22348	215,3												Nodular Limestone	1	"	set 1: 260/80
22352,5				5,4	65	6	2	3	1	1	10,8333	0,5	Nodular Limestone	1	Thrust fault 330/50	set 1: 255/85 set 2: 330/50
22358	19569			5,4	65	6	2	3	1	1	10,8333	0,5	Nodular Limestone	1	"	set 1: 255/85 set 2: 330/50 set 3: 030/90
22365	351,3			3,6	65	9	2	3	1	1	7,22222	0,5	Nodular Limestone	1	"	set 1: 255/85 set 2: 330/50

																set 3: 030/90
22371				3,3	60	9	2	3	1	1	6,66667	0,5	Nodular Limestone	1	"	set 1: 255/85 set 2: 330/50 set 3: 030/90
22377	18013			5,4	65	9	2	2	1	1	7,22222	0,75	Nodular Limestone	1	"	set 1: 255/85 set 2: 330/50 set 3: 030/90
22382,5	5169,7			5,0	60	9	2	2	1	1	6,66667	0,75	Nodular Limestone	1	"	set 1: 255/85 set 2: 330/50 set 3: 030/90
22388				5,4	65	9	2	2	1	1	7,22222	0,75	Nodular Limestone	1	diabase stop in roof Fault 262/85	set 1: 260/70 set 2: 002/70
Sum	89812															

22411	46553	6	7758,8	5,4	65	6	2	3	1	1	10,8333	0,5	Nodular Limestone	1	Fault ll layering	set 1: 255/70 set 2: 030/45
22405 Sum	46553	Hang wall thrust		3,6	65	9	2	3	1	1	7,22222	0,5	Nodular Limestone	1		set 1: 260/70 set 2: 002/70
22489	7010,2			3,1	55	9	2	3	1	1	6,11111	0,5	Limestone	3	Fault 5 cm 020/50 from	set 1: 255/80 set 2: 170/70 set 3: 030/40
22495		11,5	609,6	3,3	60	9	2	3	1	1	6,66667	0,5	Limestone	3	"	set 1: 255/80 set 2: 170/70 set 3: 030/40
22500,5				2,1	50	9	2	4	1	1	5,55556	0,38	Limestone	3	"	set 1: 255/80 set 2: 170/70 set 3: 030/40
Sum	7010,2															

22506	12592			3,1	50	6	2	4	1	1	8,33333	0,38	Limestone	3		set 1: 255/80 set 2: 170/90 set 3: 030/50
22511		16	1589,1	7,5	60	6	2	2	1	1	10	0,75	Limestone	3		set 1: 255/80 set 2: 170/90 set 3: 030/50

22516				4,2	50	9	2	2	1	1	5,55556	0,75	Limestone	3		set 1: 255/70
22522	12834			8,1	65	6	2	2	1	1	10,8333	0,75	Limestone	3		set 1: 255/70 set 2: 180/60
Sum	25426	Hang wall thrust														

22593				7,5	60	6	2	2	1	1	10	0,75	Claystone	2	calcite vein 010/80 crushed rock and reverse structures 230/20	set 1: 256/70 set 2: 007/90 set 3: 230/20
22598		16	1074,4	8,1	65	6	2	2	1	1	10,8333	0,75	Nodular Limestone	1	" "	set 1: 256/70 set 2: 007/90 set 3: 230/20
22604	17190			7,5	60	6	2	2	1	1	10	0,75	Nodular Limestone	1	Trust fault structures	set 1: 256/70 set 2: 007/90
22609				7,2	65	6	2	3	1	1	10,8333	0,67	Nodular Limestone	1	" "	set 1: 260/80 set 2: 187/80
Sum	17190															

Appendix D3
Folded sections

Folded sections

Chainage no	Grout take	Length of section	Grout pr. m tunnel	Q-value	RQD	Jn	Jr	Ja	Jw	SRF	RQD/Jn	Jr/Ja	Lithology		Strike/dip
20311,5	23992			5,4	65	9	1,5	2	1	1	7,22222	0,75	Nodular Limestone	1	set 1: 255/60
20317				8,8	70	6	1,5	2	1	1	11,6667	0,75	Nodular Limestone	1	set 1: 255/60
20323	232,1			5,0	60	6	1,5	3	1	1	10	0,5	Nodular Limestone	1	set 1: 083/70 set 2: 122/90
20327,5		60	1201,3	4,6	55	6	1,5	3	1	1	9,16667	0,5	Nodular Limestone	1	set 1: 083/70 set 2: 122/90
20333	17497			7,5	60	6	1,5	2	1	1	10	0,75	Nodular Limestone	1	set 1: 083/70 set 2: 122/90
20338,5	3203,4			4,6	55	6	1,5	3	1	1	9,16667	0,5	Nodular Limestone	1	set 1: 083/70 set 2: 122/90
20344				4,6	55	6	1,5	3	1	1	9,16667	0,5	Nodular Limestone	1	set 1: 083/70 set 2: 122/90
20349,5	20277			4,6	55	6	1,5	3	1	1	9,16667	0,5	Nodular Limestone	1	set 1: 083/70 set 2: 122/90
20355				4,2	50	6	1,5	3	1	1	8,33333	0,5	Nodular Limestone	1	set 1: 083/70 set 2: 122/90
20360,5				4,6	55	6	1,5	3	1	1	9,16667	0,5	Nodular Limestone	1	set 1: 083/70 set 2: 122/90
20366	6878,8			4,2	50	6	1,5	3	1	1	8,33333	0,5	Nodular Limestone	1	set 1: 083/70 set 2: 122/90
20371,5				3,8	60	6	1,5	4	1	1	10	0,375	Nodular Limestone	1	set 1: 083/70 set 2: 122/90
Sum	72080														
20445	595,2			7,5	60	6	1,5	2	1	1	10	0,75	Nodular Limestone	1	set 1: 082/70 set 2: 176/90
20452	31991			5,6	50	6	2	3	1	1	8,33333	0,6667	Nodular Limestone	1	set 1: 082/70 set 2: 176/90
20457				8,8	70	6	1,5	2	1	1	11,6667	0,75	Nodular Limestone	1	set 1: 082/70 set 2: 176/90
20463	1636,4			5,0	60	6	1,5	3	1	1	10	0,5	Nodular Limestone	1	set 1: 082/70 set 2: 176/90

20469	13863	62	1833,8	5,4	65	6	1,5	2	0,7	1	10,8333	0,75	Nodular Limestone	1	set 1: 251/10
20473,5				7,5	60	6	1,5	2	1	1	10	0,75	Nodular Limestone	1	set 1: 251/20
20479				5,8	70	9	1,5	2	1	1	7,77778	0,75	Nodular Limestone	1	set 1: 251/20
20485	3292,9			6,3	75	9	1,5	2	1	1	8,33333	0,75	Nodular Limestone	1	set 1: 250/30 set 2: 176/85 set 3: 060/60
20490	54483			4,2	75	9	1,5	3	1	1	8,33333	0,5	Nodular Limestone	1	set 1: 250/30 set 2: 176/85 set 3: 060/60
20495				4,4	80	9	1,5	3	1	1	8,88889	0,5	Nodular Limestone	1	set 1: 250/30 set 2: 176/85
20500,5				3,6	65	9	1,5	3	1	1	7,22222	0,5	Nodular Limestone	1	set 1: 250/30 set 2: 176/85
20507	7831,2			3,9	70	9	1,5	3	1	1	7,77778	0,5	Nodular Limestone	1	set 1: 250/30 set 2: 176/85

Sum 113693

21941				4,6	55	6	1,5	3	1	1	9,16667	0,5	Claystone	2	set 1: 258/90 set 2: 350/90
21944	25065			4,6	55	6	1,5	3	1	1	9,16667	0,5	Claystone	2	set 1: 258/90 set 2: 350/90
21949,5	4125,4			5,0	60	6	1,5	3	1	1	10	0,5	Claystone	2	set 1: 258/90 set 2: 350/90
21952,5		33	1898,5	5,0	60	6	1,5	3	1	1	10	0,5	Claystone	2	set 1: 258/90 set 2: 350/90
21958				6,7	60	6	2	3	1	1	10	0,6667	Claystone	2	set 1: 258/90 set 2: 350/90
21964	24773			4,2	50	6	1,5	3	1	1	8,33333	0,5	Claystone	2	set 1: 258/90 set 2: 350/90
21968,5	8687,5			5,0	60	6	1,5	3	1	1	10	0,5	Claystone	2	set 1: 258/90 set 2: 350/90
21974				3,6	65	9	1,5	3	1	1	7,22222	0,5	Claystone	2	set 1: 075/60

Sum 62650

21980	930,2			2,5	60	9	1,5	4	1	1	6,66667	0,375	Claystone	2	set 1: 075/60
21986	24192	17	2002,8	5,4	65	6	1,5	3	1	1	10,8333	0,5	Nodular Limestone	1	set 1: 075/60
21991	8925,6			2,5	60	9	1,5	4	1	1	6,66667	0,375	Nodular Limestone	1	set 1: 075/60
21997				3,8	60	6	1,5	4	1	1	10	0,375	Nodular Limestone	1	set 1: 255/75 set 2: 355/80

Sum 34048 Fault

22242	23018			4,2	75	9	1,5	3	1	1	8,33333	0,5	Nodular Limestone	1	set 1: 255/80 set 2: 000/70
22247,5	1565,9			5,8	70	9	1,5	2	1	1	7,77778	0,75	Nodular Limestone	1	set 1: 255/80 set 2: 000/70
22253		45	2227,2	5,8	70	9	1,5	2	1	1	7,77778	0,75	Nodular Limestone	1	set 1: 255/80 set 2: 000/70
22264	39954			5,4	65	9	1,5	2	1	1	7,22222	0,75	Nodular Limestone	1	set 1: 255/70 set 2: 030/90
22270	598,4												Not mapped		
22281,5				12,5	75	6	2	2	1	1	12,5	1	Nodular Limestone	1	
22287	35090												Not mapped		

Sum 100225

22682		5	6079,4	8,3	75	9	2	2	1	1	8,33333	1	sandstone	4	set 1: 253/30 set 2: 193/80
22687	30397			3,9	70	9	1,5	3	1	1	7,77778	0,5	sandstone	4	set 1: 065/60 set 2: 013/65

Sum 30397

23578				1,5	65	9	2	3	1	2,5	7,22222	0,6667	Limestone	3	set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23578				1,8	70	9	2	3	1	2,5	7,77778	0,6667	Limestone	3	set 1: 253/15 set 2: 282/15 set 3: 195/85 set 4: 120/80
23580	6256,4												Limestone	3	set 1: 242/30 set 2: 195/85 set 3: 112/80
23580	556,9												Limestone	3	set 1: 242/30 set 2: 195/85 set 3: 112/80
23582				1,7	75	6	2	3	1	5	12,5	0,6667	Limestone	3	set 1: 102/80 set 2: 195/85 set 3: 212/55
23591				2,5	75	6	2	2	1	5	12,5	1	Limestone	3	set 1: 102/80 set 2: 195/85 set 3: 212/55
23592	7657,5			1,5	60	6	1,5	2	1	5	10	0,75	Limestone	3	set 1: 102/80 set 2: 195/85 set 3: 212/55
23595				1,6	65	6	1,5	2	1	5	10,8333	0,75	Limestone	3	set 1: 102/80 set 2: 195/85 set 3: 212/55
23595				0,8	75	6	1	3	1	5	12,5	0,3333	Limestone	3	set 1: 102/80 set 2: 195/85 set 3: 212/55
23598				0,8	75	6	1	3	1	5	12,5	0,3333	Limestone	3	set 1: 278/90 set 2: 195/85 set 3: 150/85
23600		62	1206,6	2,3	70	6	2	2	1	5	11,6667	1	Limestone	3	set 1: 278/90 set 2: 060/75 set 3: 140/85
23600				1,4	85	9	1,5	2	1	5	9,44444	0,75	Limestone	3	set 1: 278/90 set 2: 060/75 set 3: 140/85
23603	4584,7			1,2	70	9	1,5	2	1	5	7,77778	0,75	Limestone	3	set 1: 278/45 set 2: 060/75 set 3: 140/80
23603	2272,6			2,6	80	6	2	2	1	5	13,3333	1	Limestone	3	set 1: 278/90 set 2: 060/75 set 3: 140/85

23605				1,6	60	6	1,5	2	1	5	10	0,75	Limestone	3	set 1: 260/20 set 2: 052/75 set 3: 108/80
23605				1,1	65	9	1,5	2	1	5	7,22222	0,75	Limestone	3	set 1: 260/45 set 2: 060/75 set 3: 108/80
23611				1	60	6	1,5	3	1	5	10	0,5	Limestone	3	set 1: 260/20 set 2: 052/75 set 3: 108/80
23613	1528,9												Limestone	3	set 1: 260/20 set 2: 052/75 set 3: 108/80
23613	5469			0,45	40	9	1,5	3	1	5	4,44444	0,5	Limestone	3	set 1: 260/20 set 2: 052/75 set 3: 108/80
23616				0,4	35	9	1,5	3	1	5	3,88889	0,5	Limestone	3	set 1: 260/20 set 2: 052/75 set 3: 108/80
23622	6945,6			0,2	30	9	1	3	0,7	5	3,33333	0,3333	Limestone	3	set 1: 260/30 set 2: 052/75 set 3: 158/90
23622	8311,6												Limestone	3	set 1: 260/30 set 2: 052/75 set 3: 158/90
23631	9561,2												Nodular Limestone	1	set 1: 260/30 set 2: 052/75 set 3: 158/90
23631	2562												Nodular Limestone	1	set 1: 260/30 set 2: 052/75 set 3: 158/90
23634				0,26	35	9	1,5	3	0,7	5	3,88889	0,5	Nodular Limestone	1	set 1: 260/30 set 2: 052/75 set 3: 158/90
23640	10672														
23640	8429,4														
Sum	74808														

Appendix D4
Sections cut by dikes

Dikes in sections

Chainage no	Grout take	Length of section	Grout pr. m tunnel	Q-value	RQD	Jn	Jr	Ja	Jw	SRF	RQD/Jn	Jr/Ja	Lithology		Strike/dip
19885	25098	5	5019,5	5,4	65	6	2	3	1	1	10,8	0,5	Claystone	2	set 1: 075/45 set 2: 179/85
19890				9,4	75	6	2	2	1	1	12,5	0,75	Claystone	2	set 1: 075/45 set 2: 359/85
Sum	25098	Fault													
20162,5	21105	5,5	3837,3	6,3	75	9	2	2	1	1	8,3	0,75	Limestone	3	set 1: 258/50 set 2: 190/90 set 3: 008/30
20168				4,2	75	9	2	3	1	1	8,3	0,5	Limestone	3	set 1: 258/50 set 2: 190/90 set 3: 008/30
Sum	21105														
20195,5	21353			13,3	80	6	2	2	1	1	13,3	1	Nodular Limestone	1	set 1: 252/80 set 2: 091/60
20201				12,5	75	6	2	2	1	1	12,5	1	Nodular Limestone	1	set 1: 252/80 set 2: 091/60
20206,5	546,3	33	1950,5	9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1	set 1: 252/80 set 2: 091/60
20213	32456			9,4	75	6	2	2	1	1	12,5	0,75	Nodular Limestone	1	set 1: 254/50 set 2: 172/70
20217,5				8,8	70	6	2	2	1	1	11,7	0,75	Nodular Limestone	1	set 1: 254/50 set 2: 172/70
20222	565			10,6	85	6	2	2	1	1	14,2	0,75	Nodular Limestone	1	set 1: 254/50 set 2: 172/70 set 3: 095/60
20228,5	9447,5			6,3	75	6	2	3	1	1	12,5	0,5	Nodular Limestone	1	set 1: 254/50 set 2: 172/70 set 3: 095/60
Sum	64368	Dike 20234													
20250	16245	6	2814,1	5,8	70	6	2	3	1	1	11,7	0,5	Nodular Limestone	1	set 1: 254/70
20256	640			3,9	70	9	2	3	1	1	7,8	0,5	Nodular Limestone	1	set 1: 254/70
Sum	16885														

20295	17534	6,5	2697,5	5,4	65	9	2	2	1	1	7,2	0,75	Nodular Limestone	1	set 1 :255/60 set 2: 120/90
20301,5				5,4	65	9	2	2	1	1	7,2	0,75	Nodular Limestone	1	set 1 :255/60 set 2: 120/90
Sum	17534														
20618	408	5	4694,5	5,4	65	6	2	3	1	1	10,8	0,5	Nodular Limestone	1	set 1: 255/30 set 2: 355/75-90
20623	23065												Nodular Limestone	1	set 1: 255/30 set 2: 355/75-90
Sum	23473	Dike 20624													
22018	3093,8	3	7702,5	4,4	60	9	2	3	1	1	6,7	0,6667	Claystone	2	set 1: 255/50 set 2: 355/80
22021	20014			7,2	65	6	2	3	1	1	10,8	0,6667	Claystone	2	set 1: 255/50 set 2: 355/80
Sum	23108	Fault													
22416	10788			3,3	60	9	2	3	1	1	6,7	0,5	Nodular Limestone	1	set 1: 255/70 set 2: 030/45
22422	26756	21	2741,2	3,3	60	9	2	3	1	1	6,7	0,5	Nodular Limestone	1	set 1: 255/70 set 2: 030/45
22427	231,1			3,3	60	9	2	3	1	1	6,7	0,5	Nodular Limestone	1	set 1: 255/70 set 2: 002/90
22437	19790			3,6	65	9	2	3	1	1	7,2	0,5	Nodular Limestone	1	set 1: 255/70 set 2: 002/90
Sum	57565	Dike 22442													
22695				5,8	70	6	2	4	1	1	11,7	0,5	Limestone	3	set 1: 065/60 set 2: 013/65
22703	40550	27,5	2932,7										Limestone	3	set 1: 070/60 set 2: 013/65
22711,5				3,3	60	9	2	3	1	1	6,7	0,5	Limestone	3	set 1: 070/60 set 2: 005/65
22717				2,2	40	6	1	3	1	1	6,7	0,3333	Limestone	3	set 1: 078/85 set 2: 005/85
22722,5	40098			2,8	50	9	2	3	1	1	5,6	0,5	Limestone	3	set 1: 078/85 set 2: 005/85 set 3: 123/30
Sum	80648														

22743,5				8,3	75	9	2	2	1	1	8,3	1	Interbedded sandstone + limestone	4	set 1: 075/80 set 2: 000/20
22749				3,9	70	9	2	3	1	1	7,8	0,5	Interbedded sandstone + limestone	4	set 1: 260/80 set 2: 010/80
22755	34268	28,5	3193,6	3,1	55	9	2	3	1	1	6,1	0,5	Interbedded sandstone + limestone	4	set 1: 260/80 set 2: 010/80
22761				5,8	70	6	2	3	1	1	11,7	0,5	Limestone	3	set 1: 080/70 set 2: 000/80
22766,5				8,8	70	6	2	2	1	1	11,7	0,75	Limestone	3	set 1: 080/70 set 2: 000/80
22772	56749			8,1	65	6	2	2	1	1	10,8	0,75	Limestone	3	set 1: 080/70 set 2: 000/80
Sum	91017														

Appendix E
Rose diagram data

Chainage no.	Layering strike/dip	Set 2	Set 3	Set 4
19867	set 1: 075/60	163/70	215/85	
19874	set 1: 070/45	163/70	215/85	

19885	set 1: 075/45	179/85		
19890	set 1: 075/45	359/85		

19895	set 1: 075/45	359/85		
19901	set 1: 075/45	359/85		
19906,5	set 1: 075/30	359/85		
19911	set 1: 075/30	359/85		
19917	set 1: 075/30	359/85		
19923	set 1: 064/30	100/85		
19928,5	set 1: 064/30	100/85		
19934	set 1: 064/30	100/85		
19950	set 1: 250/05	148/70		

19960	set 1: 250/05	148/70		
19966	set 1: 250/05	148/90		
19972	set 1: 250/05	148/90	030/90	
19978	set 1: 250/05	148/90		

19984	set 1: 250/05	148/90		
19989	set 1: 250/05	148/90	025/90	
19994,5	set 1: 250/10	148/90	025/90	
20000	set 1: 250/20	070/70	173/90	
20005	set 1: 250/20	070/70	320/90	
20010,5	set 1: 250/20	070/70	173/90	300/15
20017	set 1: 250/20	070/70	173/90	300/15
20021,5	set 1: 250/40	150/80	205/45	
20027	set 1: 250/20	150/80	205/45	205/45
20032	set 1: 250/20	207/10		
20039	set 1: 250/20	329/90		
20043,5	set 1: 250/20	329/90		

20048	set 1: 250/20	329/90		
20060	set 1: 250/30	329/90		
20065	set 1: 250/30	329/90		
20070,5	set 1: 250/30	329/90		
20076,5	set 1: 250/30	329/90		
20081	set 1: 250/30	329/90		
20088	set 1: 250/45	320/90		

20094	set 1: 250/45			
20097	set 1: 250/45			
20100,5	set 1: 254/50	350/90		
20106,5	set 1: 254/50	000/80	032/60	
20112	set 1: 254/50	350/90		

20117	set 1: 254/50	350/90		
20122,5	set 1: 254/50	350/90		
20130	set 1: 254/50	350/90		
20145,5	set 1: 254/50	350/90		
20151,5	set 1: 254/50	350/90		
20157	set 1: 254/50	008/80		

20162,5	set 1: 258/50	190/90	008/30	
20168	set 1: 258/50	190/90	008/30	

20168	set 1: 258/50	190/90	008/30	
20173	set 1: 258/50	190/90	008/30	
20178	set 1: 258/50	190/90	008/30	248/70
20184,5	set 1: 258/60	190/90		
20190	set 1: 258/60	190/90		

20195,5	set 1: 252/80	091/60		
20201	set 1: 252/80	091/60		
20206,5	set 1: 252/80	091/60		
20213	set 1: 254/50	172/70		
20217,5	set 1: 254/50	172/70		

20222	set 1: 254/50	172/70	095/60	
20228,5	set 1: 254/50	172/70	095/60	

20234	set 1: 254/50	172/70	095/60	

20239	set 1: 254/70			
20245	set 1: 254/70			

20250	set 1: 254/70			
20256	set 1: 254/70			

20256	set 1: 254/70			
20262	set 1: 254/70			
20267,5	set 1: 254/70			
20274	set 1: 254/70			
20280	set 1: 254/70			
20284	set 1: 254/70			
20290	set 1 :255/60	120/90		

20295	set 1 :255/60	120/90		
20301,5	set 1 :255/60	120/90		

20301,5 20306,5	set 1 :255/60 set 1: 255/60	120/90		
20311,5	set 1: 255/60			
20317	set 1: 255/60			
20323	set 1: 083/70	120/90		
20327,5	set 1: 083/70	120/90		
20333	set 1: 083/70	120/90		
20338,5	set 1: 083/70	120/90		
20344	set 1: 083/70	120/90		
20349,5	set 1: 083/70	120/90		
20355	set 1: 083/70	120/90		
20360,5	set 1: 083/70	120/90		
20366	set 1: 083/70	120/90		

20371,5	set 1: 083/70	120/90		
20377	set 1: 083/70			
20383,5	set 1: 083/70			
20389	set 1: 083/70			
20394,5	set 1: 083/70			
20405	set 1: 083/70			
20411	set 1: 083/70			
20418	set 1: 083/70			
20423	set 1: 083/70			
20428,5	set 1: 083/70			
20435	set 1: 083/70			
20440	set 1: 082/70	176/90		
20445	set 1: 082/70	176/90		
20452	set 1: 082/70	176/90		
20457	set 1: 082/70	176/90		
20463	set 1: 082/70	176/90		
20469	set 1: 251/10			
20473,5	set 1: 251/20			
20479	set 1: 251/20			
20485	set 1: 250/30	176/85	060/60	
20490	set 1: 250/30	176/85	060/60	
20495	set 1: 250/30	176/85		
20500,5	set 1: 250/30	176/85		
20507	set 1: 250/30	176/85		
20512	set 1: 250/30	176/85		
20518	set 1: 250/30	176/85		
20524	set 1: 250/30	130/90		
20529	set 1: 250/30	130/90		
20535	set 1: 250/30	130/90		
20541	set 1: 250/30	130/90		

20546,5	set 1: 250/30	130/90		
20550,5	set 1: 250/30	130/90		
20552	set 1: 250/30	130/90		
20556	set 1: 250/30	130/90		
20563	set 1: 255/30	120/85		
20568,5	set 1: 255/30	120/85		
20573	set 1: 255/30	120/85		
20579	set 1: 255/30	120/85		
20585	set 1: 255/30	120/85		
20590,5	set 1: 255/30	355/80		
20595	set 1: 255/30	355/80		
20601,5	set 1: 255/30	355/80		
20607	set 1: 255/30	355/80		
20612,5	set 1: 255/30	355/80		
20618	set 1: 255/30	355/80		
20623	set 1: 255/30	355/80		
20624	set 1: 255/30	355/80		
20629	set 1: 255/30			
20634	set 1: 255/30			
20640	set 1: 255/30			
20643	set 1: 255/75	355/80		
20645,5	set 1: 255/75	355/90		
20649	set 1: 255/75	355/90		
20655	set 1: 255/75	355/90		
20661	set 1: 255/75	355/90		
20667	set 1: 255/75	355/90		

20673	set 1: 255/75	355/90		
20678	set 1: 255/75	355/90		
20684	set 1: 255/75	355/90		
20689,5	set 1: 255/75	355/90		
20695,5	set 1: 255/75	355/90		
20701	set 1: 255/75	355/90		
20706,5	set 1: 255/75	355/90		
20713	set 1: 255/75	355/90		
20718,5	set 1: 255/75	355/90		
20722	set 1: 255/75	355/90		
20724	set 1: 260/60	200/90	330/90	
20729,5	set 1: 260/60	200/90	330/90	
20735	set 1: 260/60	200/90	330/90	
20740	set 1: 260/60	200/90	330/90	
20746	set 1: 260/70			
20753	set 1: 260/70	034/10		
20756	set 1: 260/70	034/10		
20757,5	set 1: 260/70	034/10		
20763	set 1: 260/70	034/10	350/30	
20768,5	set 1: 260/80	034/10		
20775	set 1: 260/80	034/10		
20775	set 1: 260/80	034/10		
20779,5	set 1: 260/80	106/90		
20786	set 1: 260/80	034/10		
20791	set 1: 260/60	350/80	118/45	
20795,5	set 1: 260/60	350/80	118/45	
20801	set 1: 260/60	350/80		
20806	set 1: 260/60	350/80	093/45	

20812	set 1: 260/60	350/80	118/60	
20818	set 1: 260/60			
20824	set 1: 260/50			
20829,5	set 1: 260/50			
20834,5	set 1: 260/50	350/80		
20840	set 1: 260/50	350/80		
20845,5	set 1: 260/60			
20851	set 1: 260/60			

20856,5	set 1: 260/60	170/80		
20862	set 1 :255/70	170/80		
20867	set 1 :255/70	170/80		
20873	set 1 :255/70	170/80		
20879	set 1 :255/70	170/80		
20884,5	set 1 :255/70	170/80		
20890	set 1 :255/70	170/80		
20901	set 1 :255/70	170/80		
20906	set 1: 254/70			

20911	set 1: 254/70			
20918	set 1: 254/70			
20925	set 1 :255/70	149/30		
20928	set 1 :255/70	149/30		
20933	set 1 :255/70	149/30	255/30	

20939	set 1 :255/70	255/30		
20944	set 1 :255/70	255/30		
20949	set 1 :255/70	255/30		
20955	set 1 :255/70	350/80		
20958	set 1 :255/70	350/80		
20965	set 1: 248/80	350/80		
20967	set 1: 248/80	350/80		
20970	set 1: 248/80	350/80		
20977	set 1: 248/80	350/80		
20982	set 1:	350/80		

	248/80			
20987	set 1: 248/80	350/80		
20993	set 1: 248/80	350/80		
20998	set 1: 258/70	178/90		
21764	set 1: 258/70	178/90		
21770	set 1: 258/70	178/90		
21775	set 1: 255/75			
21781	set 1: 255/75			
21786	set 1: 255/75			
21791	set 1: 255/75			
21795,5	set 1: 255/75			
21801	set 1: 258/70	178/90		
21806	set 1: 258/70	178/90		
21812	set 1: 258/70	178/90		
21818	set 1: 258/70	178/90		
21823,5	set 1: 258/70	178/90		
21829	set 1: 258/70	178/90		
21834,5	set 1: 258/70	178/90		
21840	set 1: 258/70	178/90		
21845,5	set 1: 258/70	178/90		
21851	set 1: 258/70	178/90		
21857	set 1: 258/70	178/90		
21862	set 1: 255/60	177/90		
21867,5	set 1: 255/60	177/90		
21873	set 1: 255/60	177/90		
21878	set 1: 255/60	178/90	215/60	
21884	set 1: 255/60	178/90	215/60	
21889	set 1: 255/60	178/90	215/60	
21895	set 1: 258/50			
21901	set 1: 078/80			

21902	set 1: 256/70	355/90		
21907,5	set 1: 256/70	355/90		
21917	set 1: 256/70	355/90		
21919	set 1: 256/70	355/90		
21922,5	set 1: 258/80	350/80		
21928	set 1: 258/80	350/80		

21930	set 1: 258/80	350/80		
21935,5	set 1: 258/80	350/80		

21941 21944	set 1: 258/90 set 1: 258/90	350/90 350/90		
21949,5	set 1: 258/90	350/90		
21952,5	set 1: 258/90	350/90		
21958	set 1: 258/90	350/90		
21964	set 1: 258/90	350/90		
21968,5	set 1: 258/90	350/90		
21974	set 1: 075/60			

21980	set 1: 075/60			
21986	set 1: 075/60			
21991	set 1: 075/60			
21997	set 1: 255/75	355/80		

22003,5	set 1: 255/75	355/90		
22010	set 1: 255/75	355/90		

22018	set 1: 255/50	355/80		
22021	set 1: 255/50	355/80		

22021	set 1: 255/50	355/80		
22026	set 1: 255/50	355/80		
22032	set 1: 255/50	355/80		

22037	set 1: 255/50	355/80		
22043,5	set 1: 255/50	355/80		

22054,5	set 1: 255/60	355/90		
22060	set 1: 255/60	355/90		
22065,5	set 1: 255/60	355/90		
22071	set 1: 255/60	355/90		
22076	set 1: 255/60	355/90		
22081,5	set 1: 255/60	355/90		
22087	set 1: 255/70			
22092,5	set 1: 255/70			
22098	set 1: 255/70	355/90	255/30	
22103,5	set 1: 255/70	355/90	255/30	

22103,5	set 1: 255/70	355/90	255/30	
22109	set 1: 255/70	355/90	255/30	

22115	set 1: 255/70	355/90		
22120	set 1: 255/70	355/90		
22128	set 1: 255/70	355/90	255/30	

22132	set 1: 255/70	355/90		
22137	set 1: 255/70			

22137	set 1: 255/70			
22143	set 1: 255/70			
22148	set 1: 255/70			
22154	set 1: 255/60	355/90		
22160	set 1: 255/60	355/90		
22165,5	set 1: 255/60	355/90		
22171	set 1: 255/70			
22175	set 1: 255/70			
22180,5	set 1: 255/70			
22187,5	set 1: 254/60			
22191	set 1:			

	254/60			
22195	set 1: 254/60			
22196,5	set 1: 254/60			
22209,5	set 1: 254/60	355/90		
22214	set 1: 254/60	355/90		
22220	set 1: 255/60			
22225,5 22231	set 1: 255/60 set 1: 255/60			
22236,5	set 1: 255/80	000/70		

22242	set 1: 255/80	000/70		
22247,5	set 1: 255/80	000/70		
22253	set 1: 255/80	000/70		
22264	set 1: 255/70	030/90		
22270				
22281,5				
22287				

22292,5	set 1: 260/90	355/70		
22297,5	set 1: 260/90	355/70		
22303	set 1: 260/90	355/70		
22309	set 1: 260/90	355/70		

22314	set 1: 260/90			
22320	set 1: 260/85			
22325	set 1: 078/83			
22330,5	set 1: 078/83			
22336	set 1: 078/83			
22342	set 1: 260/80			
22347	set 1: 260/80			
22348	set 1: 260/80			
22352,5	set 1: 255/85	330/50		
22358	set 1: 255/85	330/50	030/90	
22365	set 1: 255/85	330/50	030/90	
22371	set 1: 255/85	330/50	030/90	
22377	set 1: 255/85	330/50	030/90	

22382,5	set 1: 255/85	330/50	030/90	
22388	set 1: 260/70	002/70		

22394	set 1: 260/70	002/70		
22399	set 1: 260/70	002/70		
22405	set 1: 260/70	002/70		

22411	set 1: 255/70	030/45		
22405	set 1: 260/70	002/70		

22416	set 1: 255/70	030/45		
22422	set 1: 255/70	030/45		
22427	set 1: 255/70	002/90		
22437	set 1: 255/70	002/90		

22442	set 1: 255/70	002/90		
22448	set 1: 255/70	002/90		

22448	set 1: 255/70	002/90		
22454	set 1: 255/70	002/90		
22459	set 1: 255/70	002/90		
22465	set 1: 255/80	170/70		
22476	set 1: 255/80	170/70		

22489	set 1: 255/80	170/70	030/40	
22495	set 1: 255/80	170/70	030/40	
22500,5	set 1: 255/80	170/70	030/40	

22506	set 1: 255/80	170/70	030/50	
22511 22516	set 1: 255/80 set 1: 255/70	170/70	030/50	
22522	set 1: 255/70	180/60		

22528	set 1: 255/70	180/60		
22533	set 1: 255/70	180/60		

22533	set 1: 255/70	180/60		
22537	set 1: 255/70			
22544	set 1: 256/70	300/85		
22548,5	set 1: 256/70	300/85		
22555	set 1: 256/70	300/85		
22559,5	set 1: 256/70	300/85		

22559,5	set 1: 256/70	300/85		
22565	set 1: 256/70	300/85		

22572	set 1: 256/80			
22576	set 1: 256/70			
22583	set 1: 256/70			
22587	set 1: 256/70			

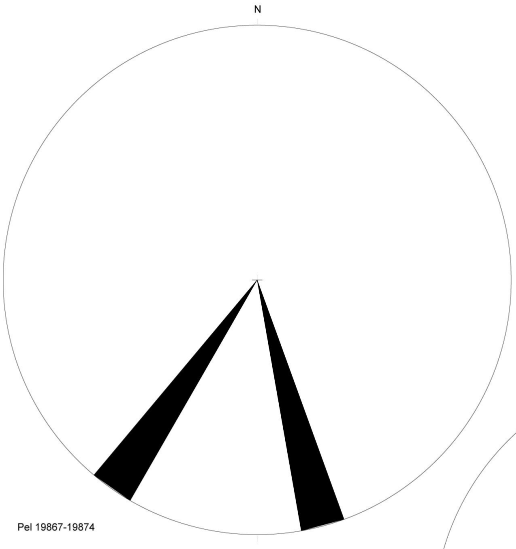
22593	set 1: 256/70	007/90	230/20	
22598	set 1: 256/70	007/90	230/20	
22604	set 1: 256/70	007/90		
22609	set 1: 260/80	187/80		

22614,5	set 1: 260/80	187/80		
22620	set 1: 260/80	187/80		
22625	set 1: 260/30	052/75	158/90	
22625,5	set 1: 260/80	187/80		
22628	set 1: 260/30	052/75	158/90	
22631	set 1: 260/80	187/80		
22638	set 1: 260/80			
22644	set 1: 260/80	195/60	139/70	
22649	set 1: 253/80	187/90		
22655	set 1: 253/80	012/85		
22660	set 1: 253/80	012/85		
22666	set 1: 253/30	012/85		
22671,5	set 1: 253/30	193/80		

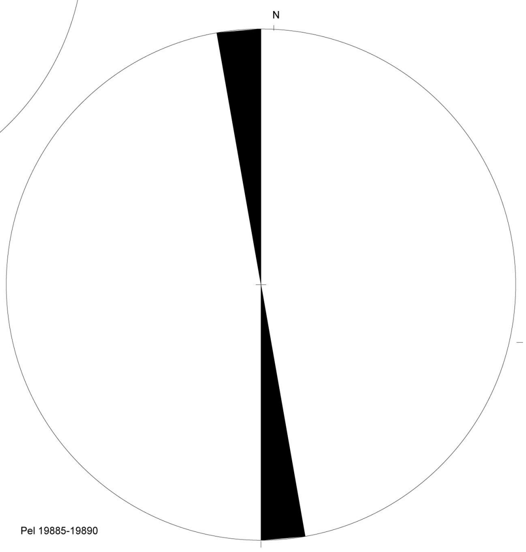
22682	set 1: 253/30	193/80		
22687	set 1: 065/60	013/65		
22695	set 1: 065/60	013/65		
22703	set 1: 070/60	013/65		
22711,5	set 1: 070/60	005/65		
22717	set 1: 078/85	005/65		
22722,5	set 1: 078/85	005/65	123/30	
22728	set 1: 078/90	005/65	123/30	
22733,5	set 1: 078/85	005/65		
22738,5	set 1: 078/90	005/65		
22743,5	set 1: 075/80	000/20		
22749	set 1: 260/80	010/80		
22755	set 1: 260/80	010/80		
22761	set 1: 080/70	000/80		
22766,5	set 1: 080/70	000/80		
22772	set 1: 080/70	000/80		
22775	set 1: 260/45	010/80		
22780	set 1: 260/45	010/80		
23540	set 1: 092/30	120/70	350/80	
23548	set 1: 092/30	120/70	350/80	
23551	set 1: 213/10	330/10	017/85	120/70
23557	set 1: 213/10	330/10	017/85	120/70
23561	set 1: 253/10	297/10	017/85	120/80
23561	set 1: 253/10	297/10	017/85	120/80
23563	set 1: 253/10	297/10	017/85	120/80
23566	set 1: 253/10	297/10	017/85	120/80
23568	set 1: 253/10	297/10	017/85	120/80
23569	set 1: 253/15	282/15	195/85	120/80
23569	set 1: 253/15	282/15	195/85	120/80
23570	set 1:	297/10	017/85	120/80

	253/10			
23571	set 1: 253/15	282/15	195/85	120/80
23575	set 1: 253/15	282/15	195/85	120/80
23578	set 1: 253/15	282/15	195/85	120/80
23578	set 1: 253/15	282/15	195/85	120/80
23578	set 1: 253/15	282/15	195/85	120/80
23580	set 1: 242/30	195/85	112/80	
23580	set 1: 242/30	195/85	112/80	
23582	set 1: 102/80	195/85	212/55	
23591	set 1: 102/80	195/85	212/55	
23592	set 1: 102/80	195/85	212/55	
23595	set 1: 102/80	195/85	212/55	
23595	set 1: 102/80	195/85	212/55	
23598	set 1: 278/90	195/85	140/85	
23600	set 1: 278/90	060/75	140/85	
23600	set 1: 278/90	060/75	140/85	
23603	set 1: 278/45	060/75	140/85	
23603	set 1: 278/90	060/75	140/85	
23605	set 1: 260/20	052/75	108/80	
23605	set 1: 260/45	060/75	108/80	
23611	set 1: 260/20	052/75	108/80	
23613	set 1: 260/20	052/75	108/80	
23613	set 1: 260/20	052/75	108/80	
23616	set 1: 260/20	052/75	108/80	
23622	set 1: 260/30	052/75	158/90	
23622	set 1: 260/30	052/75	158/90	
23631	set 1: 260/30	052/75	158/90	
23631	set 1: 260/30	052/75	158/90	
23634	set 1: 260/30	052/75	158/90	

Appendix E1
Rose diagrams



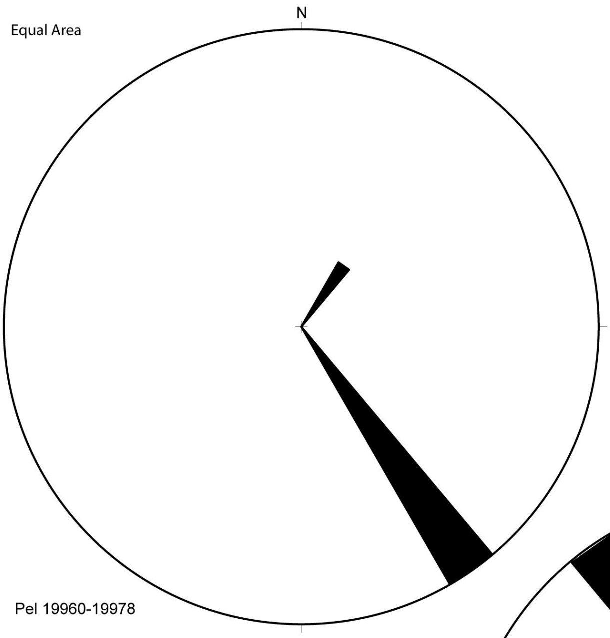
Pel 19867-19874



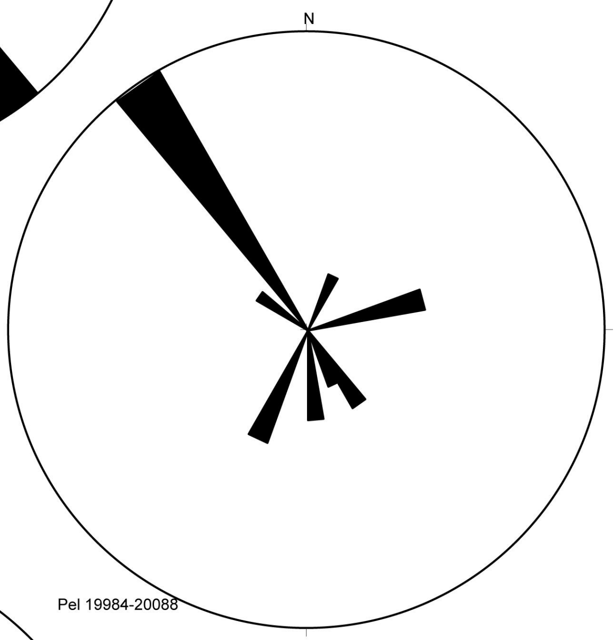
Pel 19885-19890

Pel 19895-19950

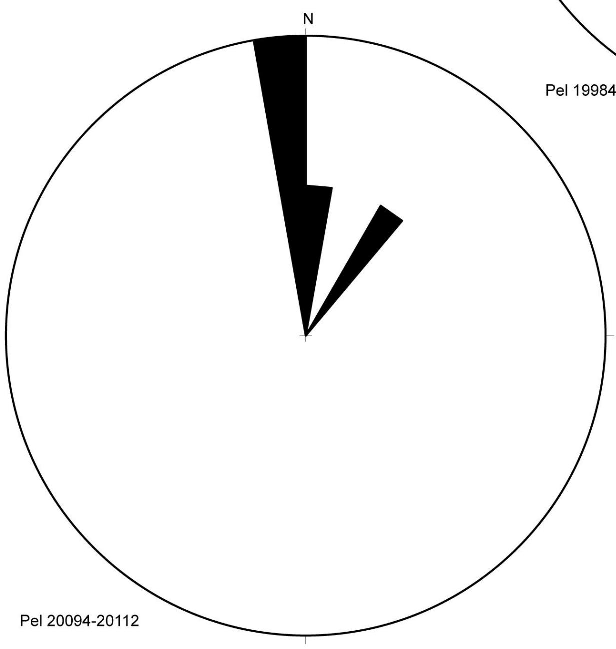
Equal Area



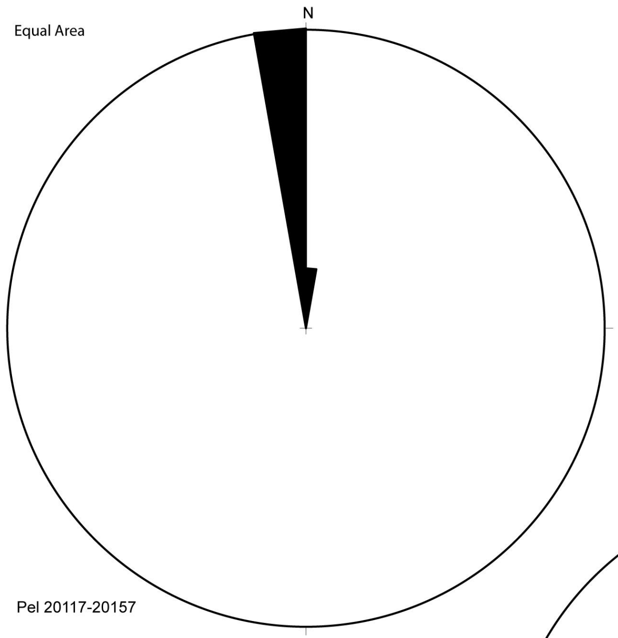
Pel 19960-19978

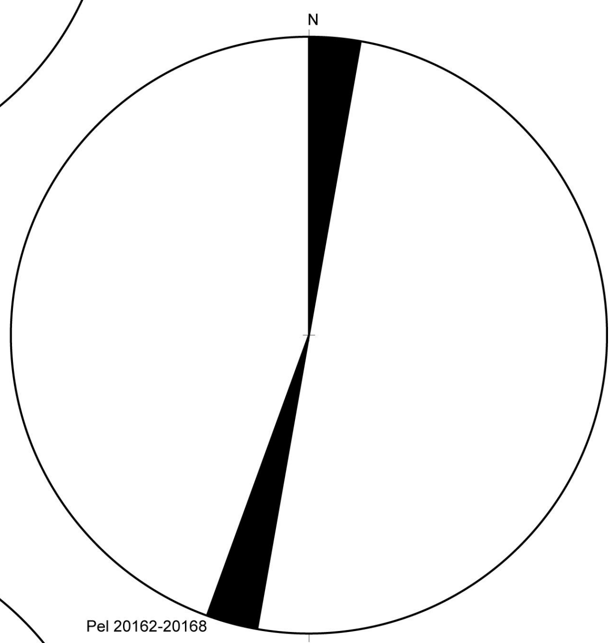


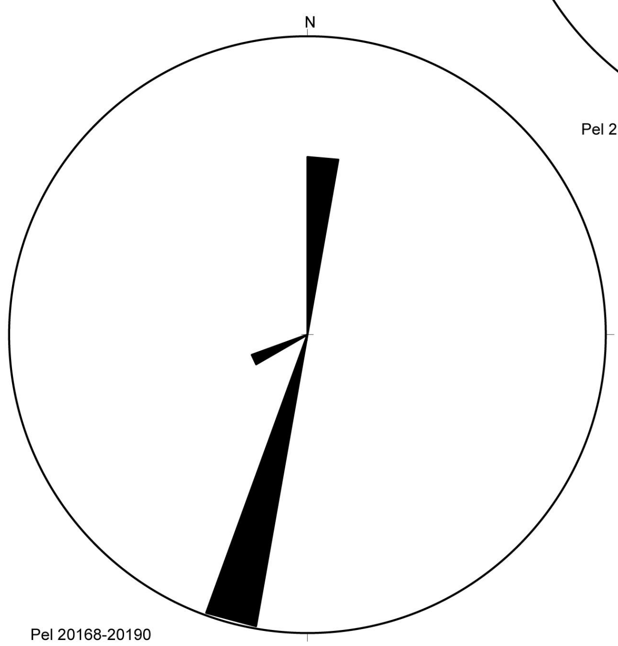
Pel 19984-20088



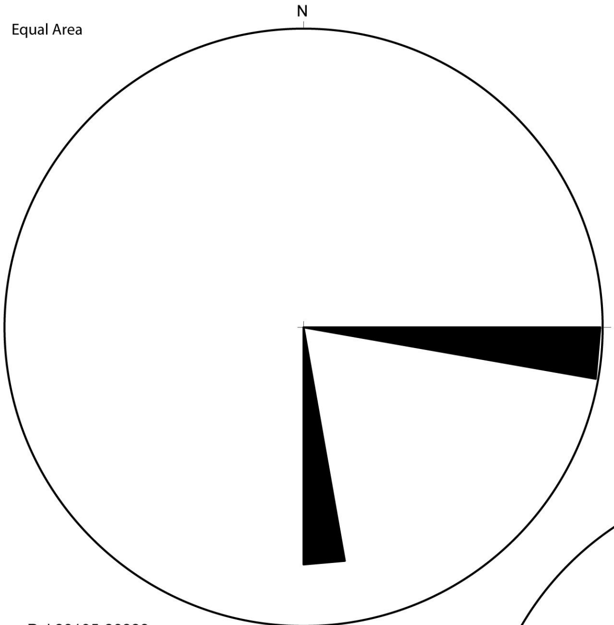
Pel 20094-20112


Equal Area
N
Pel 20117-20157

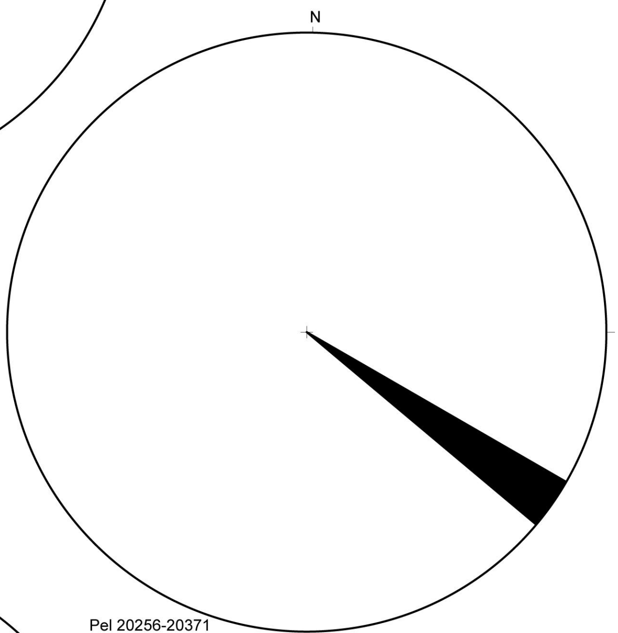

N
Pel 20162-20168


N
Pel 20168-20190

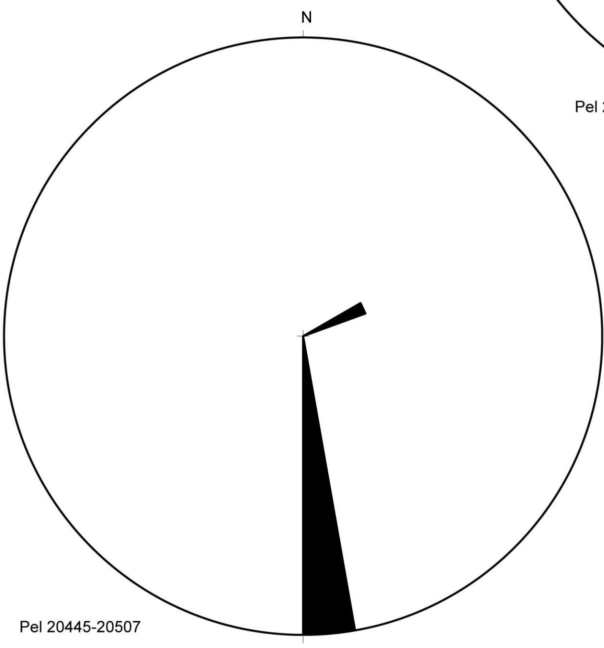
Equal Area



Pel 20195-20228

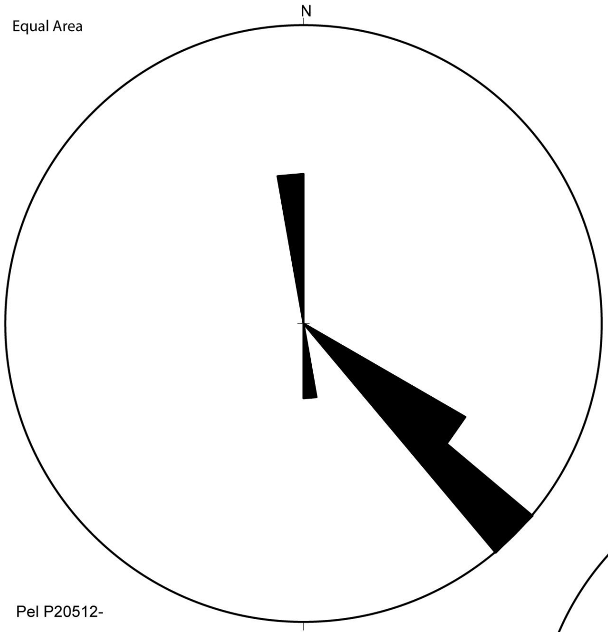


Pel 20256-20371

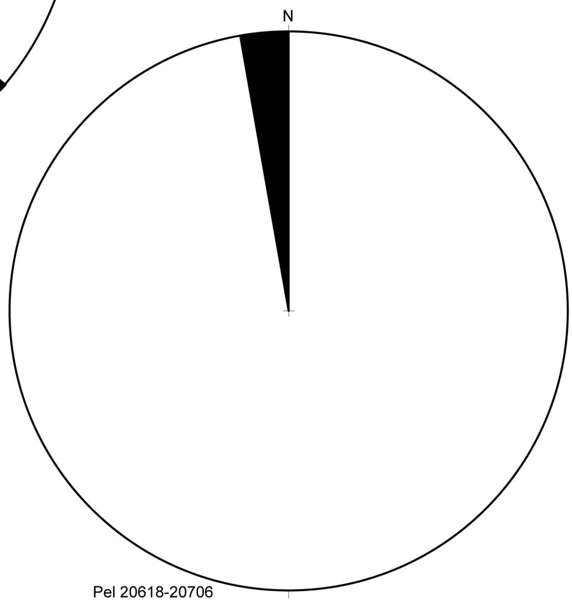


Pel 20445-20507

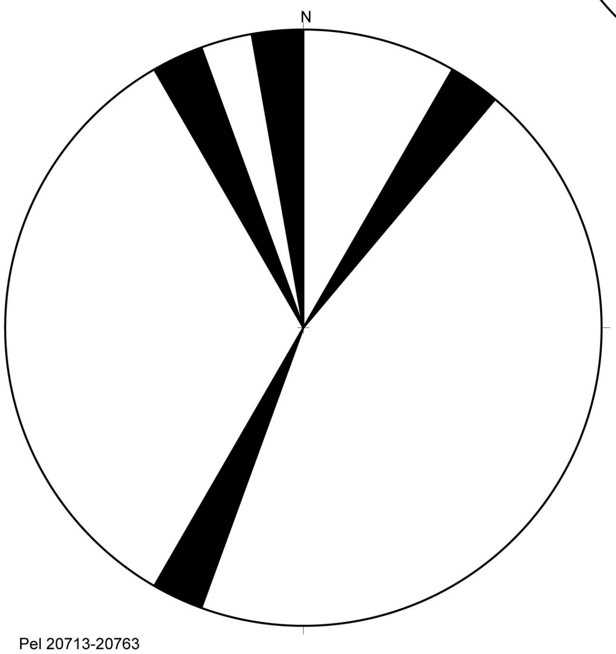
Equal Area



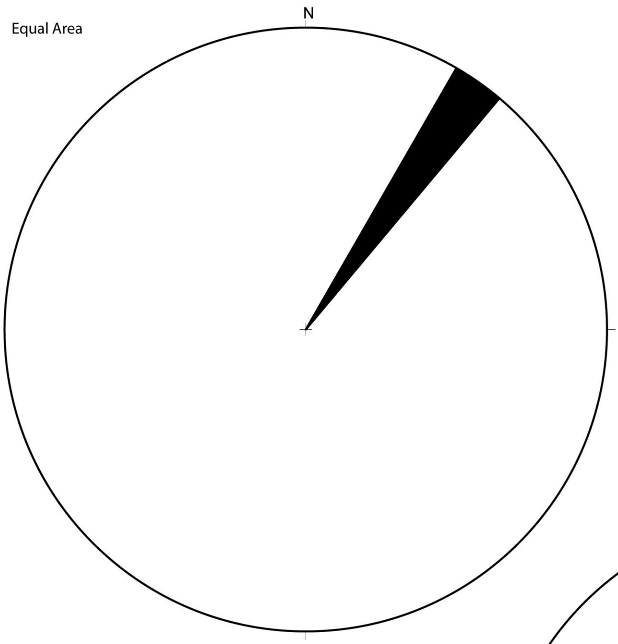
Pel P20512-



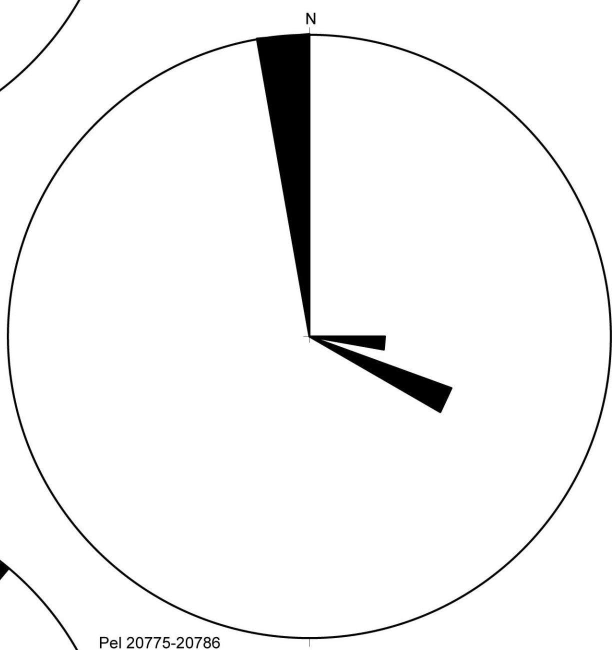
Pel 20618-20706



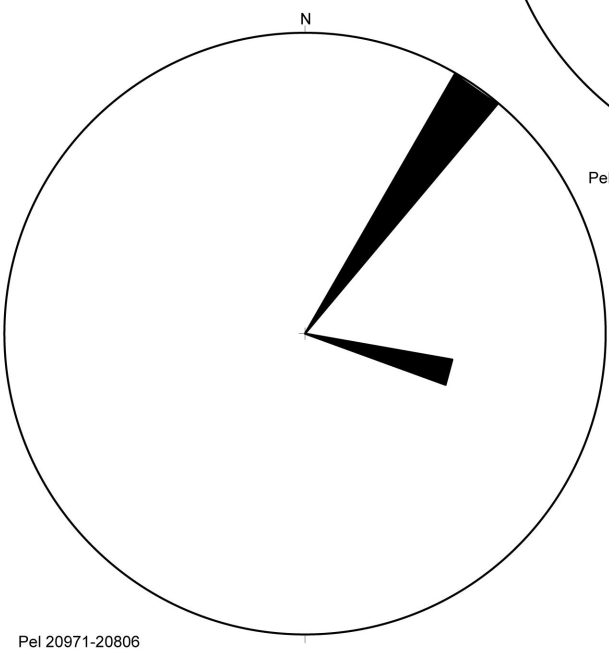
Pel 20713-20763



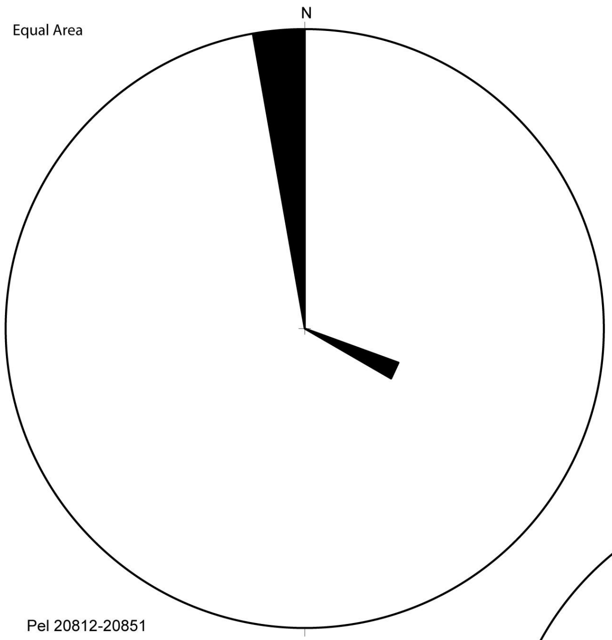
Pel 20768-20775



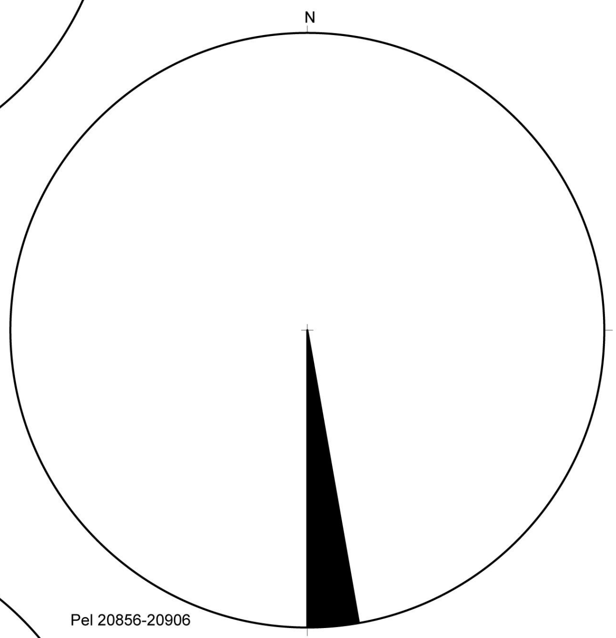
Pel 20775-20786



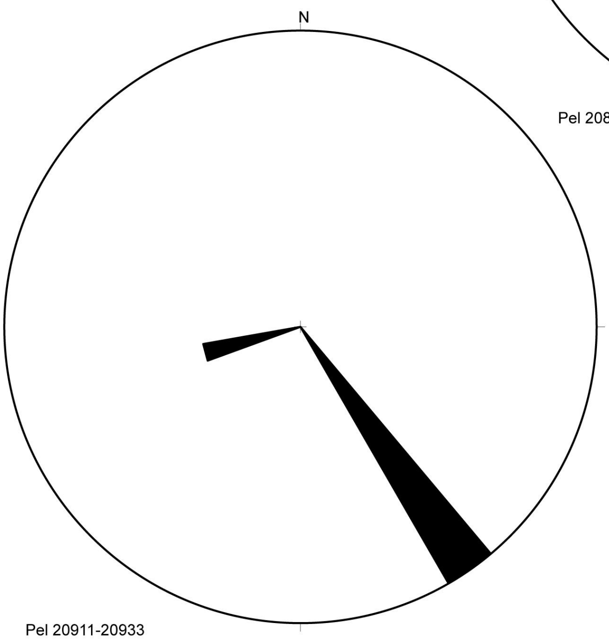
Pel 20971-20806



Pel 20812-20851

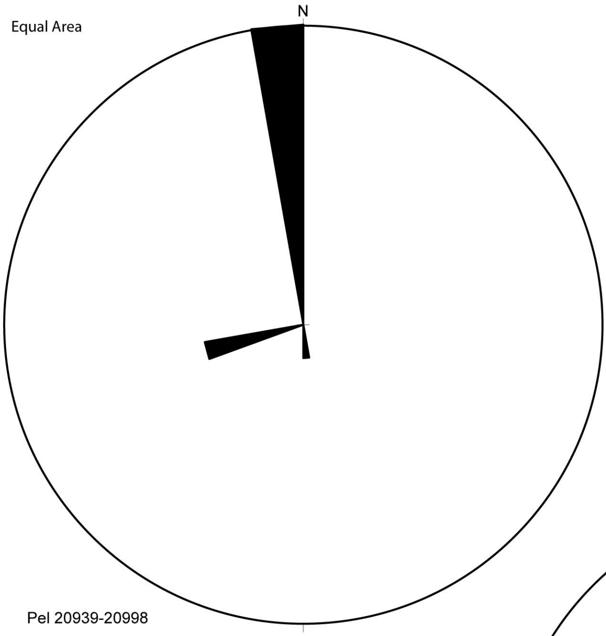


Pel 20856-20906

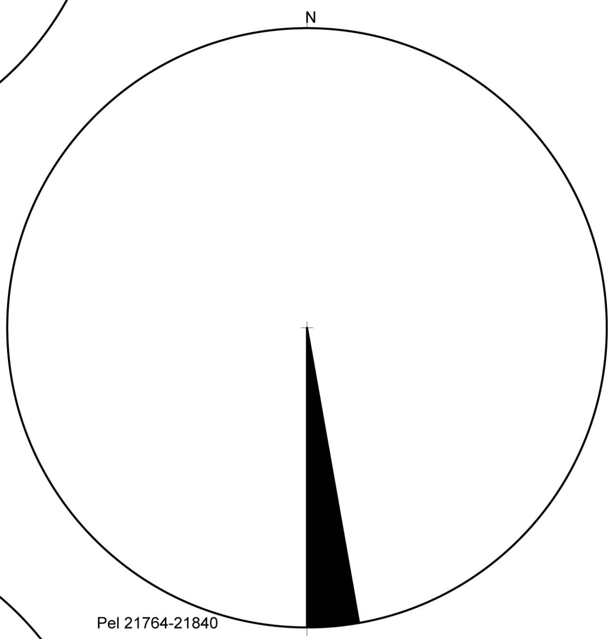


Pel 20911-20933

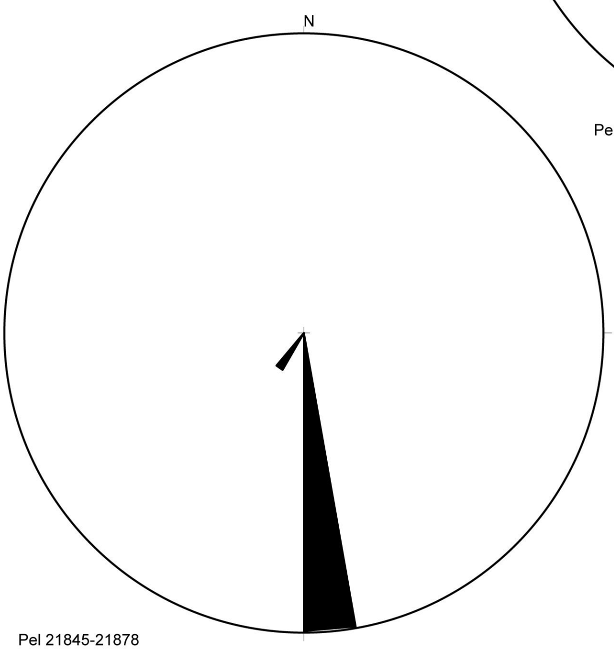
Equal Area



Pel 20939-20998

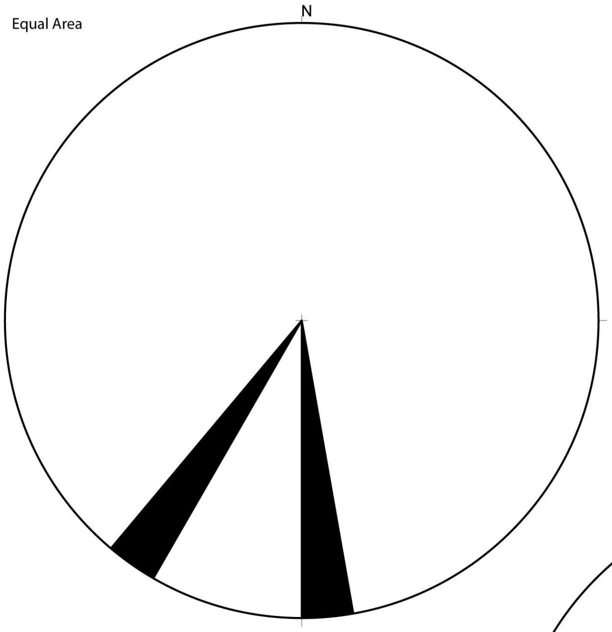


Pel 21764-21840

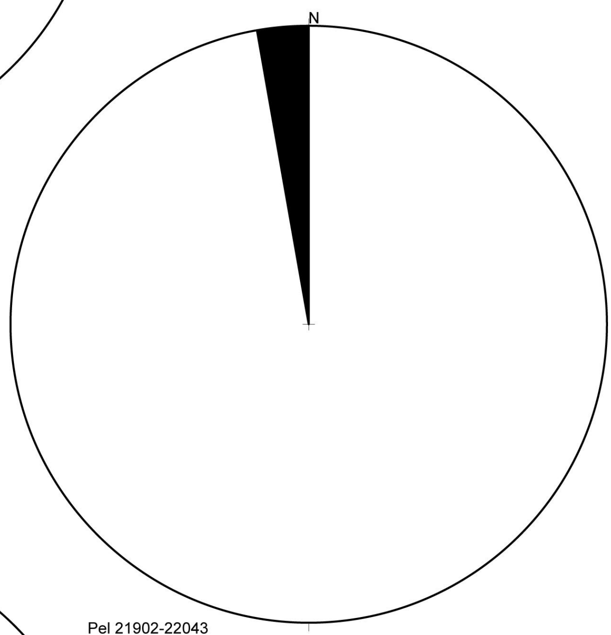


Pel 21845-21878

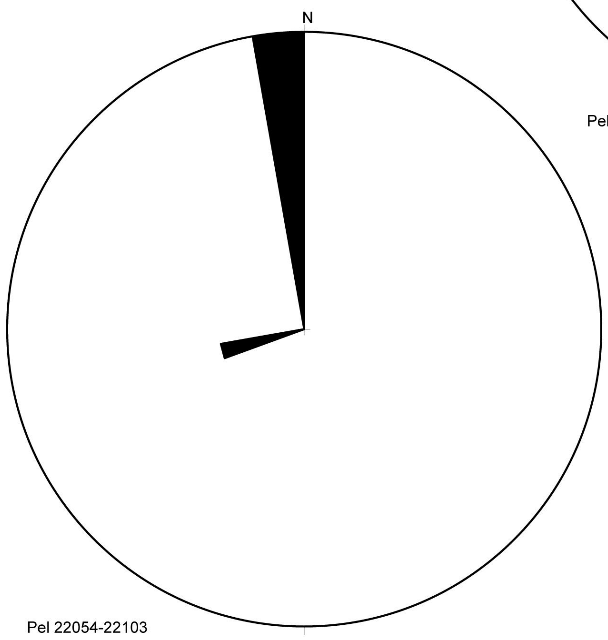
Equal Area



Pel 21884-21901

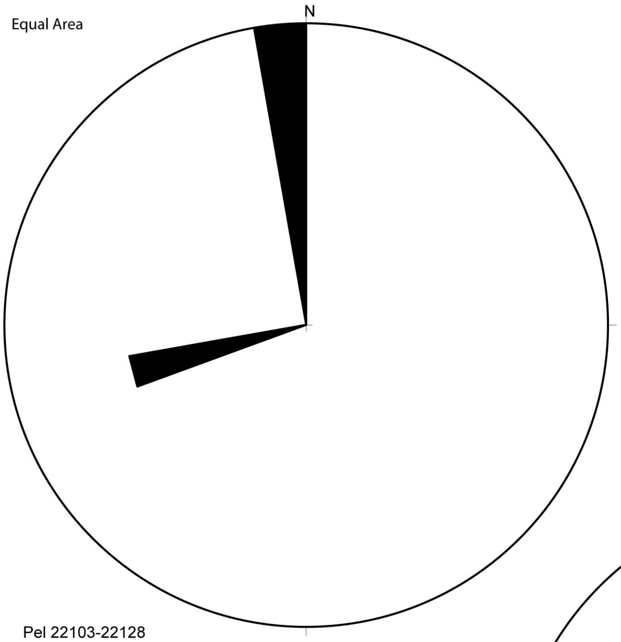


Pel 21902-22043

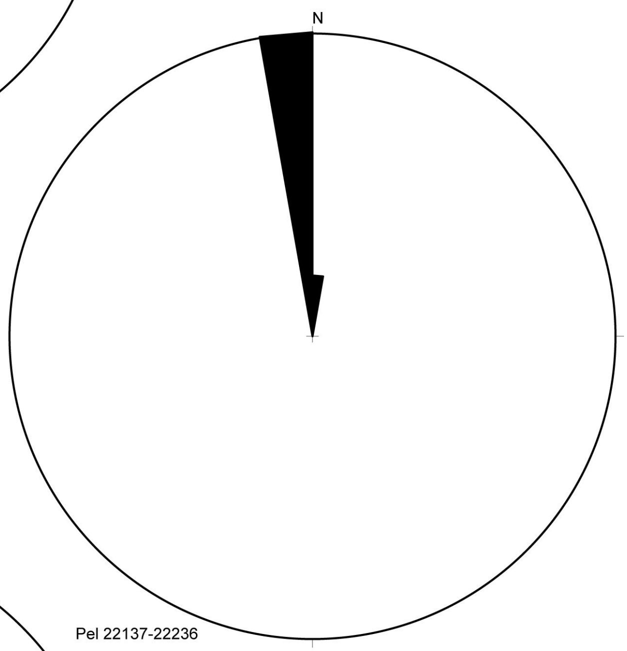


Pel 22054-22103

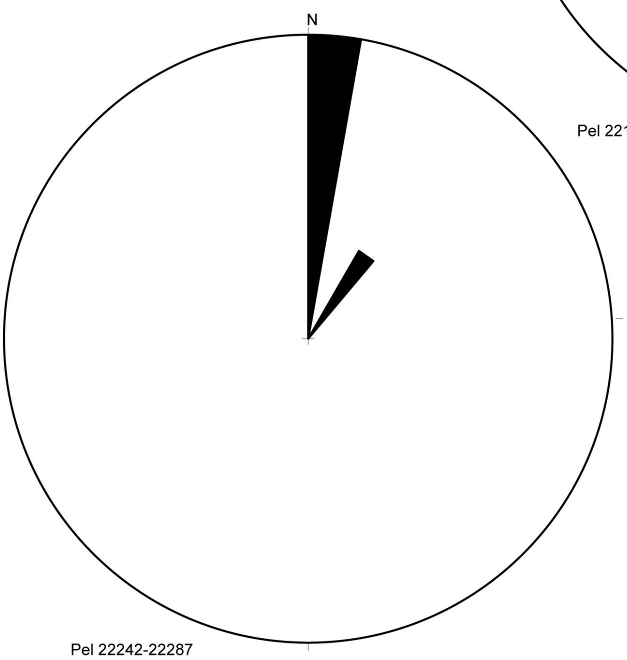
Equal Area



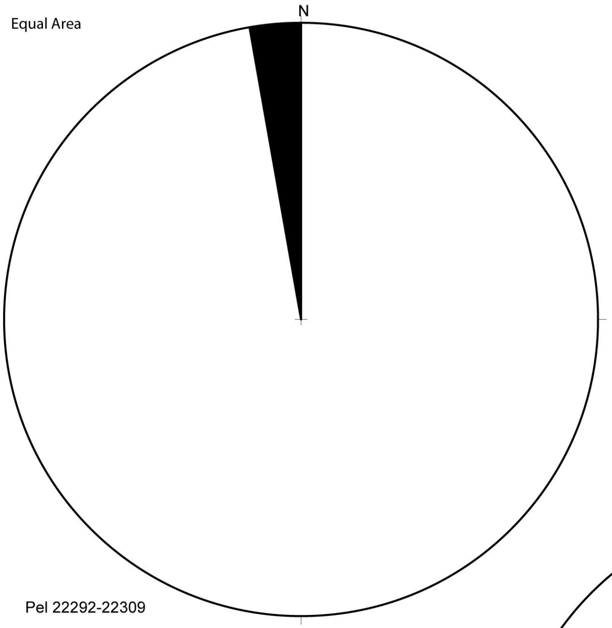
Pel 22103-22128



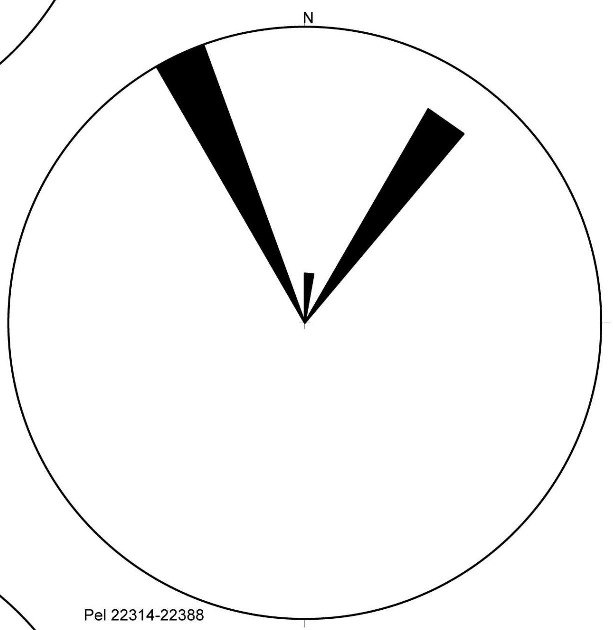
Pel 22137-22236



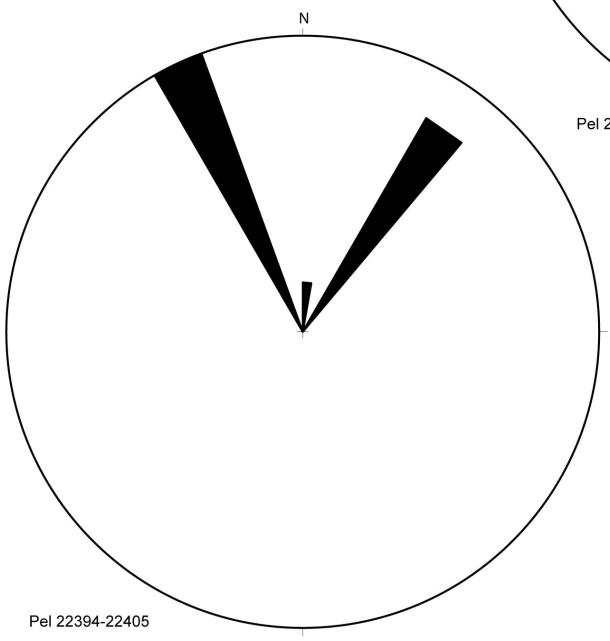
Pel 22242-22287



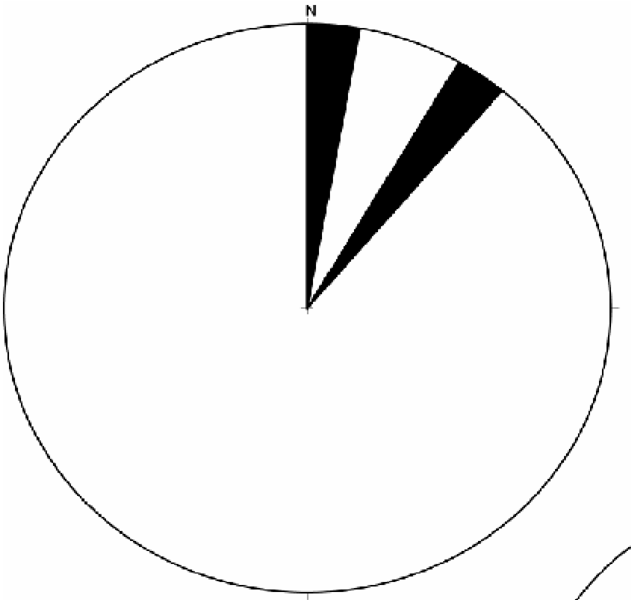
Pel 22292-22309



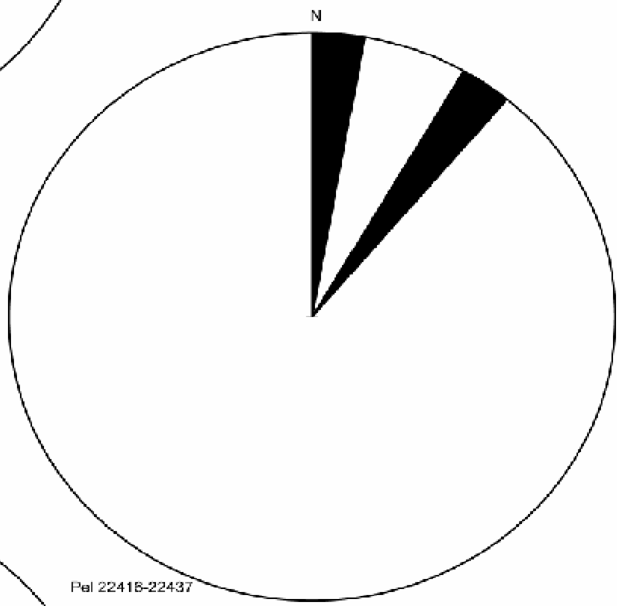
Pel 22314-22388



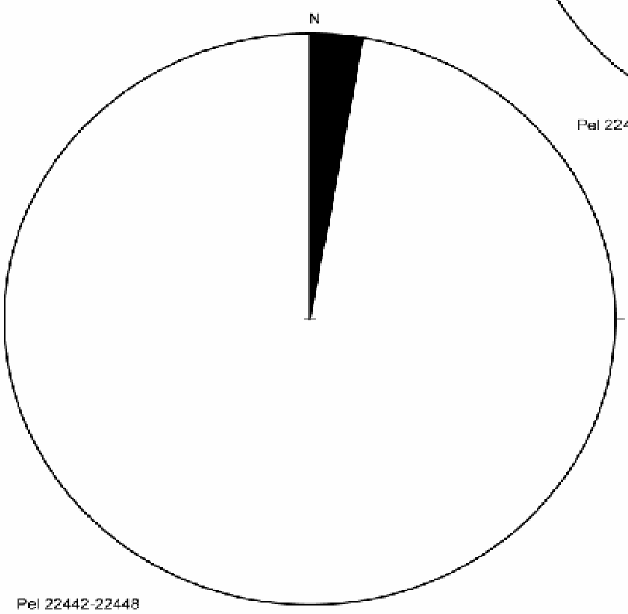
Pel 22394-22405



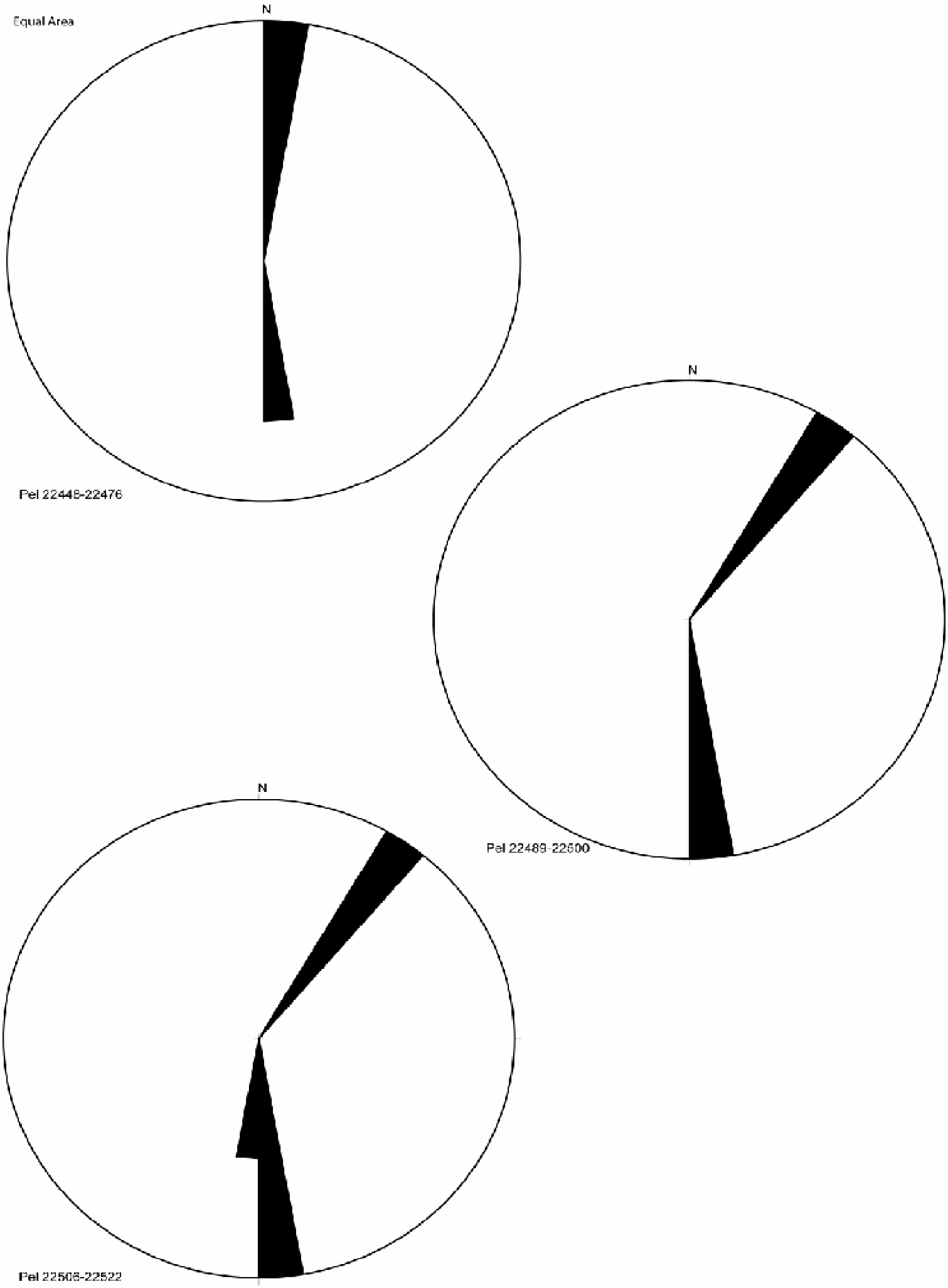
Pel 22401-22411



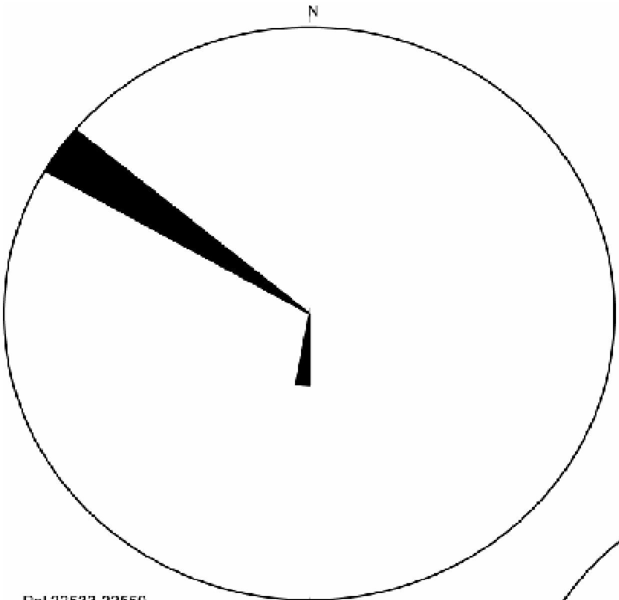
Pel 22418-22437



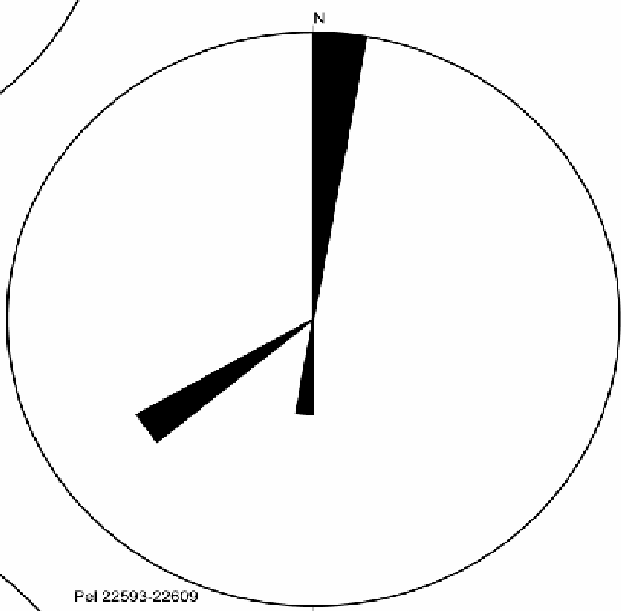
Pel 22442-22448



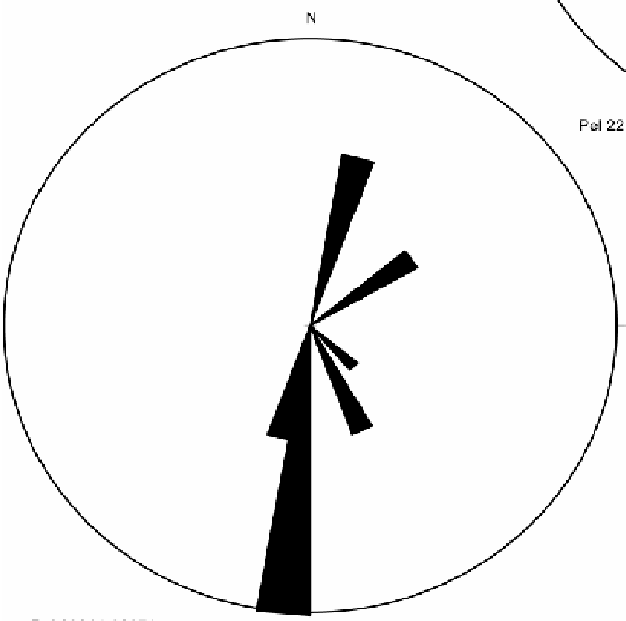
Equal Area
N
Pel 22448-22476
N
Pel 22489-22600
N
Pel 22508-22522



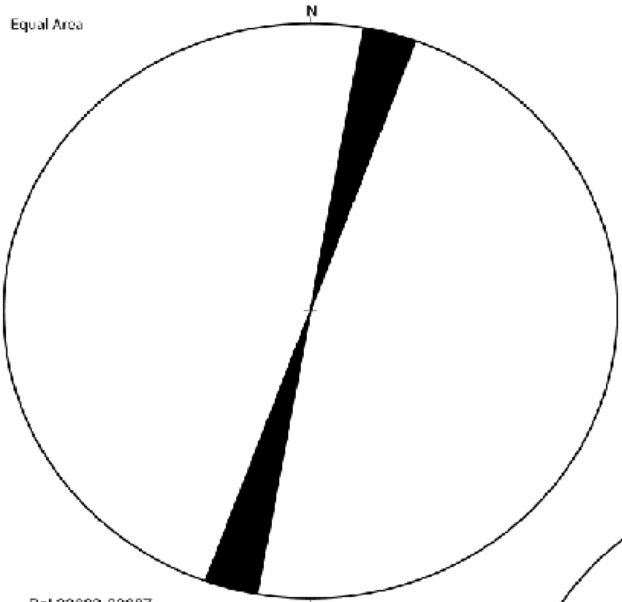
Pel 22533-22559



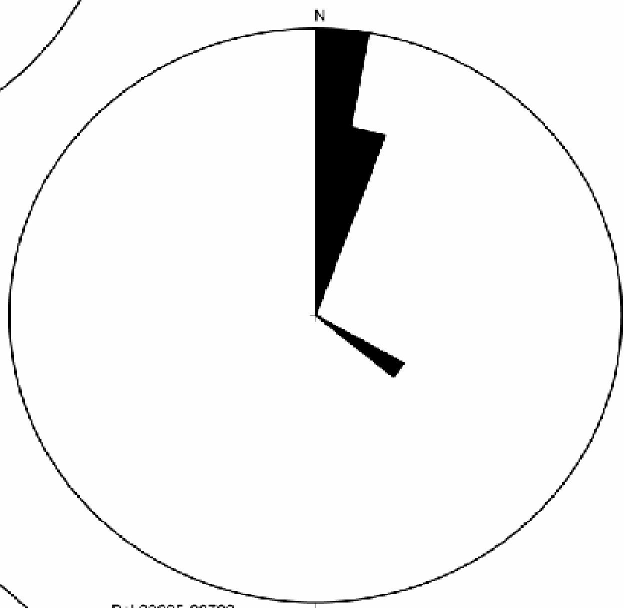
Pel 22593-22609



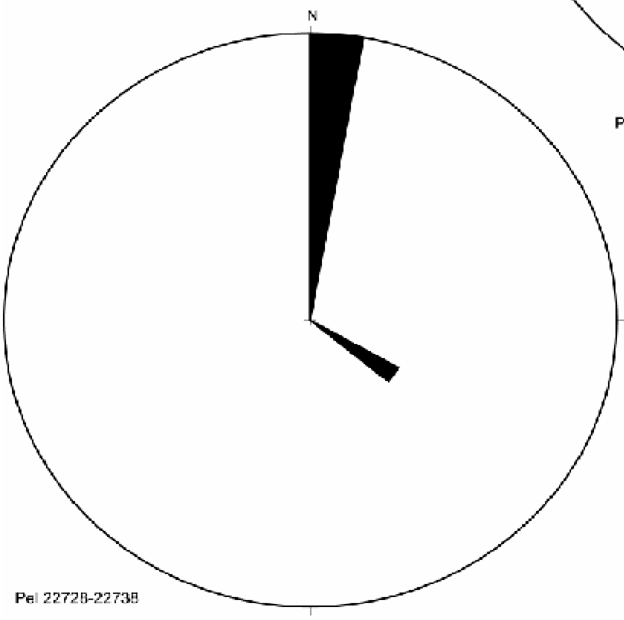
Pel 22614-22671



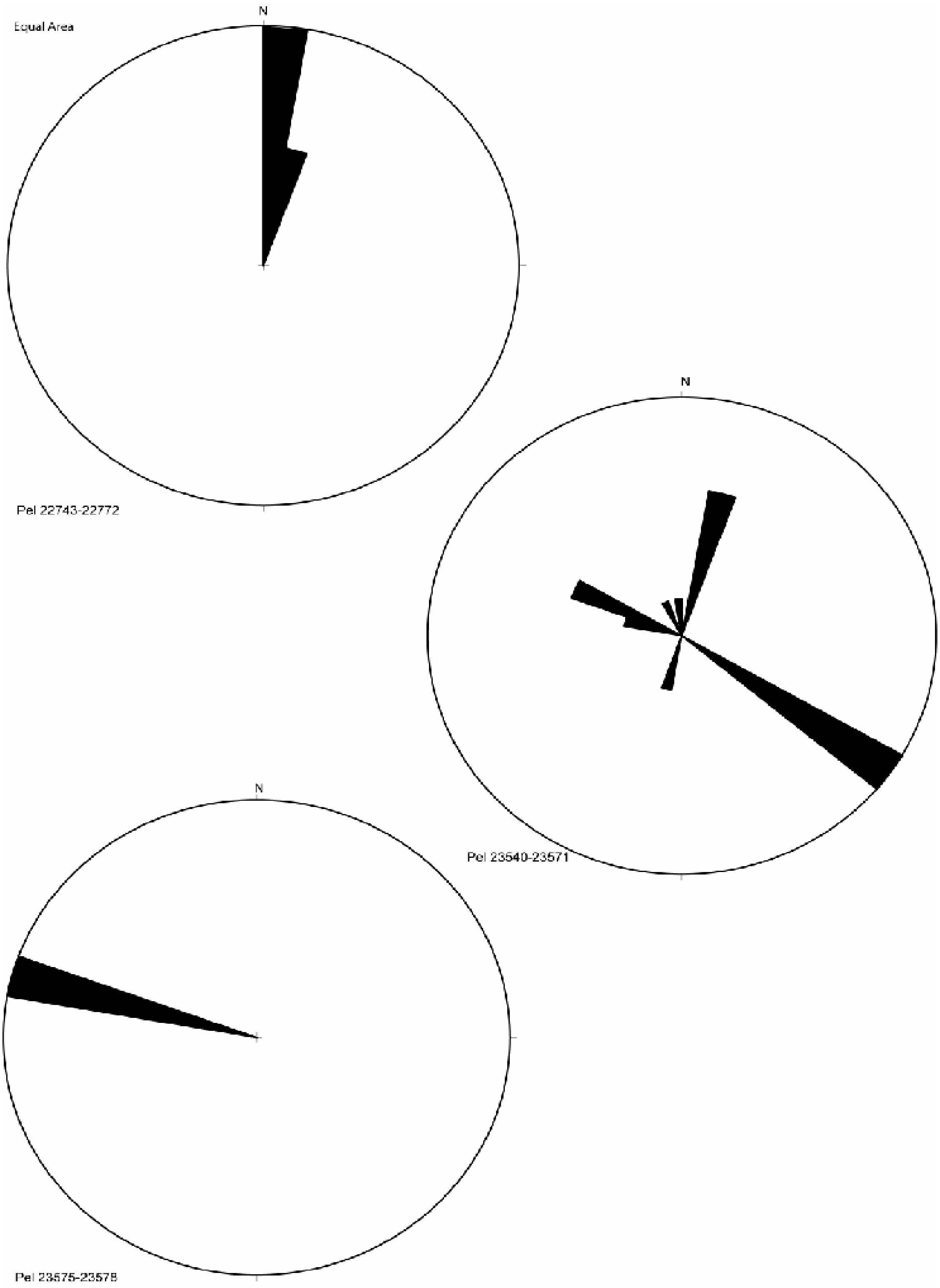
Pel 22682-22687

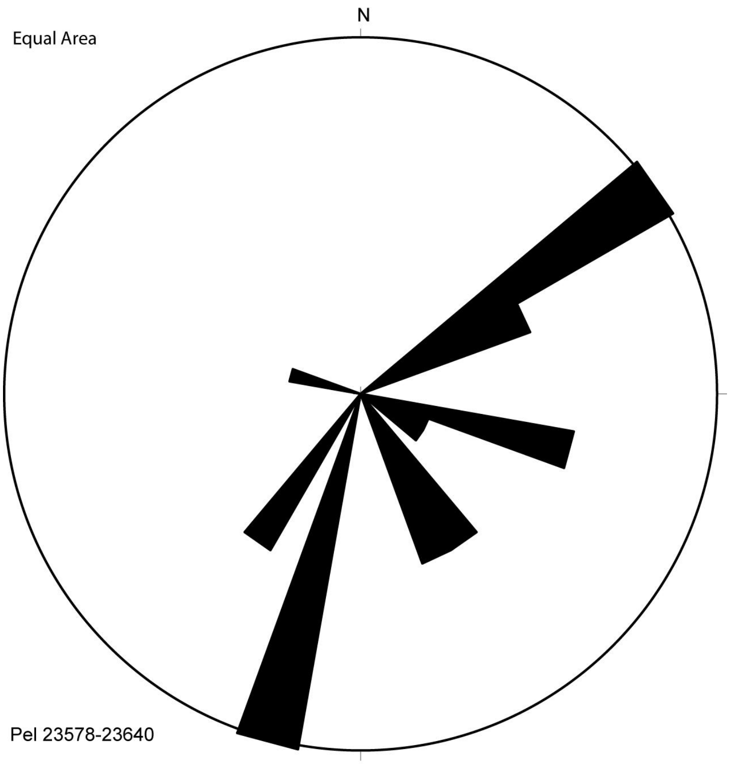


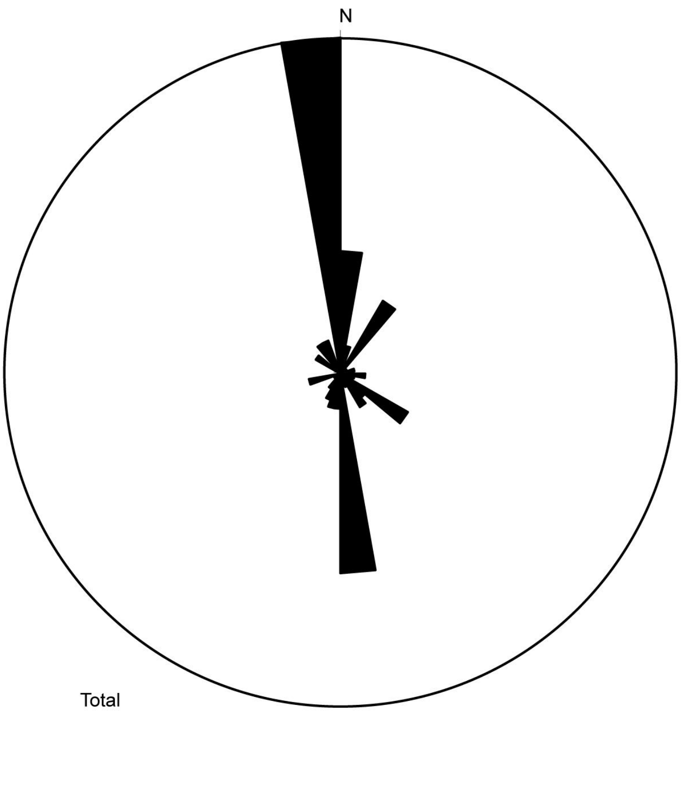
Pel 22695-22722



Pel 22728-22738


Equal Area
N
Pel 22743-22772
N
Pel 23540-23571
N
Pel 23575-23578


N
Equal Area
Pel 23578-23640


N
Total