NGU Rapport 2008-018

Brittle tectonics in the Numedalen region.
Insights into hydrogeology.

Norges geologiske undersøkelse
7491 TRONDHEIM
Tlf. 73 90 40 00
Telefaks 73 92 16 20

RAPPORT

Rapport nr.: 2008-018		Gradering: Åpen

Tittel:
Brittle tectonics in the Numedalen region. Insights into hydrogeology.

Forfatter: Saintot, A.	Oppdragsgiver: NGU
Fylke: Buskerud	Kommune: Kongsberg
Kartblad (M=1:250.000) Skien	Kartbladnr. og -navn (M=1:50.000) 1714 II Kongsberg, 1713 I Siljan
Forekomstens navn og koordinater:	Sidetall: 74 Pris: 310 NOK Kartbilag:

Feltarbeid utført:	Rapportdato:	Prosjektnr.:	Ansvarlig:
May 2005 – Oct. 2006	Feb 2008	301815	

Abstract:
The aim of this study was to determine the link between structural geology and the hydrogeological system of the Numedalen valley from Kongsberg to Hvittingfoss (Buskerud county) within the framework of the GEOS program.Three main geological units are present in the Numedalen area: (1) Precambrian basement, (2) Late Caledonian sedimentary fold-and-thrust belt and (3) Permian Oslo Rift, all having a very low porosity and intrinsic permeability. In such medium, the groundwater flow is expected to be heterogeneous, anisotropic and controlled by fractures. The analysis of the structural geology of the area is therefore required to build a proper hydrogeological model. The regional structural trends are extracted from satellite imagery and aerial orthophotos together with the spatial analyses of subsequent streams of the surficial drainage network. With such methods, 4 trends of lineaments are extracted: two predominant NW-SE and N-S trends, a well expressed NE-SW set and a minor E-W trend. In the granitic massif, the NW-SE trend is the best expressed but also a secondary NE-SW trend is present. Moving to the south-east, within the monzonite, syenite and rhomb-porphyry massifs, a large N-S trend in addition to the main NW-SE trend is present. Even if more discrete, these two trends are observed in the Precambrian rocks to the north-west together with an E-W and a NE-SW trends. The NE-SW lineaments are characteristic for the Caledonian sedimentary fold-and thrust belt unit and are parallel to the contacts between the fold-and thrust belt and the two surrounding units. 36 sites were visited in order to better characterise the nature of these different sets of discontinuities (i.e. dykes, faults, joints, lithological contact...) at different scales and to qualitatively estimate their bulk permeability. Also, a few samples were collected and thin sections made in order to characterize the fractures at the microscopic scale. The sealing of micro-fractures by minerals can be absent or incomplete and then increase the secondary (fracture) porosity of the rocks. Sampling was specifically made where highly fractured mafic dykes were observed in a less fractured host rocks. The changing of direction of the Numedalen valley between Hvittingfoss and Kongsberg is controlled by the bedrock geology and the lineaments. The NW-SE and N-S segments of the valley trend parallel to these large discontinuities that are recognised in this field study as major normal faults and mafic dykes. The large set of NE-SW lineaments also corresponds to normal faults and dykes according to the brittle structures identified at the local scale. The fault zones generally display a high permeability relatively to the host rock with an increase of fracture density and the presence of uncemented brecciated fault cores. The basaltic dykes are in general more jointed that the host rocks and it is assumed that the permeability along the dykes is significantly higher than in the host rock. The groundwater flow is likely heterogeneous, anisotropic, as controlled by these large discontinuities.

Emneord: Brittle tectonics	Hydrogeology	Numedalen
Buskerud	GEOS	

Norsk sammendrag

Formålet med dette studiet, som er del av GEOS programmet, har vært å kartlegge strukturgeologiske forhold i berggrunnen langs Numedalen mellom Kongsberg og Hvittingfoss, samt å vurdere hvilke betydning disse forhold kan ha på hydrogeologien langs dalen. Det utvalgte undersøkelsesområdet består av tre bergrunnsgeologiske hovedgrupper; (1) Prekambrisk grunnfjell, (2) Kambro-silurske sedimentære bergarter og (3) Oslofeltets permiske intrusiver. Bergartene i disse gruppene har alle har meget lav porøsitet og primær permeabilitet, og grunnvannsstrømmen er derfor styrt av bergrunnens oppsprekning. Studier av satellittbilder, ortofoto og topografiske kart er benyttet i kartleggingen av regionale strukturgeologiske strukturer og trender, og det er på bakgrunn av dette avdekket 4 hovedtrender på lineamenter i undersøkelsesområdet: to dominerende med orientering NV-SE og N-S, en tydelig NØ-SV, og en mindre utviklet Ø-V trend. I de granitiske bergartene dominerer den NV-SE trenden, men det finnes også en sekundær NØ-SV trend innen dette området. Lengre mot sør-øst, innen bergartene monsonitt, syenitt, og rombeporfyr finnes, i tillegg til den dominerende NV-SØ trenden, også en framtredende N-S trend på lineamentene. Disse to trendene finnes, om enn i mindre grad, også i det prekambriske grunnfjellet mot nord-vest, sammen med en Ø-V og en NØ-SV trend. Den kambro-silurske bergartsgruppen domineres av en NØ-SV lineamenter, som er parallell med kontaktgrensen til omliggende bergartsgrupper. Numedalen skiftende retningen mellom Kongsberg og Hvittingfoss er for en stor del styrt av beliggenhet og orienteringen på bergartsgrenser i tillegg til store lineamenter som forkastninger og gangintrusiver.

36 feltlokaliteter ble oppsøkt for å verifisere kartlegging basert på foto- og kartstudier samt å karakterisere de ulike lineamenter og oppsprekkingsmønstre (gangintrusiver, forkastninger, sprekker, bergartsgrenser mm.) ut fra et hydrogeologisk perspektiv. Det ble også tatt bergartsprøver fra noen få lokaliteter, hovedsakelig fra godt oppsprukne gangintrusiver, til tynnslippreparering for å studere sprekkekarakteristika som på mikroskala.

Feltobservasjonene indikerer at forkastningssonene normalt har høy sprekkefrekvens og med åpne strukturer selv i knusningssonene. De kartlagte basaltiske gangintrusivene er også gjennomgående mer oppsprukket enn omliggende berggrunn, og har som følge av dette en betydelig høyere permeabilitet enn omliggende bergrunn. Ut fra disse observasjonene er det forventet at slike intrusiver i kombinasjon med større forkastningssoner har avgjørende betydning på grunnvannsstrømmen i berggrunnen i området.

TABLE OF CONTENT

INTRODUCTION

This study along the Numedalen valley, from Kongsberg to Hvittingfoss (Buskerud county) was carried out within the framework of the GEOS program. The aim of the study was to determine the link between structures and the hydrogeological system of the Numedalen valley. The geology of the area comprises three specific tectonic units, which, from southeast to northwest, are: (1) the border of the Late Palaeozoic Oslo Rift and its magmatic succession, (2) the Late Caledonian sedimentary fold-and-thrust belt (with Cambro-Ordovician deposits) and (3) the Precambrian basement. They all correspond to media of low porosity. In such setting, the hydrogeology and specifically the groundwater flow, if any, is highly dependent of the fracturation of the medium. Therefore, a study of structural geology and specifically, of brittle structures, is required to define the role of fractures in the hydrogeological system of the valley.
The term 'discontinuity' herein applies to (1) first order, regional lineaments (faults, dykes, lithological contact) and to (2) second order structures, such as joints, minor faults and dykes observed at the scale of the outcrop. A special effort is made to characterise the nature of discontinuities (dykes, faults, joints...) at different scales and to qualitatively estimate their hydraulic parameters. A brief overview of the possible hydraulic properties of brittle structures is given and is the basis for the conclusive qualitative remarks on the role of the large brittle structures in the hydrogeological system of the Numedalen valley. Large fracture zones can have a relatively high permeability and act as flow conduits for the groundwater, resulting in a strong anisotropy in the direction of the groundwater flow. Another parameter that is of importance for the permeability of the rock mass and the groundwater flow is the density of open fractures, their connectivity and their spatial distribution (referred to as secondary permeability). Generally, an increase of fracture density is expected close to the regional-scale faults. As for an end-of–scale fracturation analysis, a sparse sampling of dykes (that fill many large discontinuities) and their host rocks was carried out in order to characterise the micro-fractures in thin-sections and the occurrence of secondary (fracture) porosity.

1 GEOLOGICAL SETTING OF THE NUMEDALEN VALLEY

The following geological description is based on a review of the existing geological literature.

Three main tectonic units are present in the Numedalen area (Figure 1A and B): (1) the Precambrian basement, (2) the Late Caledonian sedimentary fold-and-thrust belt (with Cambro-Ordovician sedimentary deposits) and (3) the Permian Oslo Rift units comprising intrusive massifs, lava flows and many intruded mafic dykes (the dykes are not displayed on the 1/250000 scale map of Figure 1B). The main geological discontinuities are the NE-SW contacts between these units NW-SE to NNW-SSE and N-S trending large lineaments (highlighted by the surficial drainage network at both scale of displayed maps on Figure 1) (Note: a more specific analysis of the first order discontinuities is made in paragraph 2.3; the nature of them is characterised in the field and presented in paragraph 2.4). As the valley between latitudes 6608000 and 6597000 trends also NNW-SSE (segment C on Figure 1B), it strongly suggests that its development was tectonically controlled. The valley NE from Hvittingfoss also clearly follows along the contact between two distinct Permian magmatic units, the rhomb porphyries and the syenites (segment D on Figure 1B) (Note: the map at 1/250000 does not display the numerous syenitic lenses in the monzonite massif north of segment D).

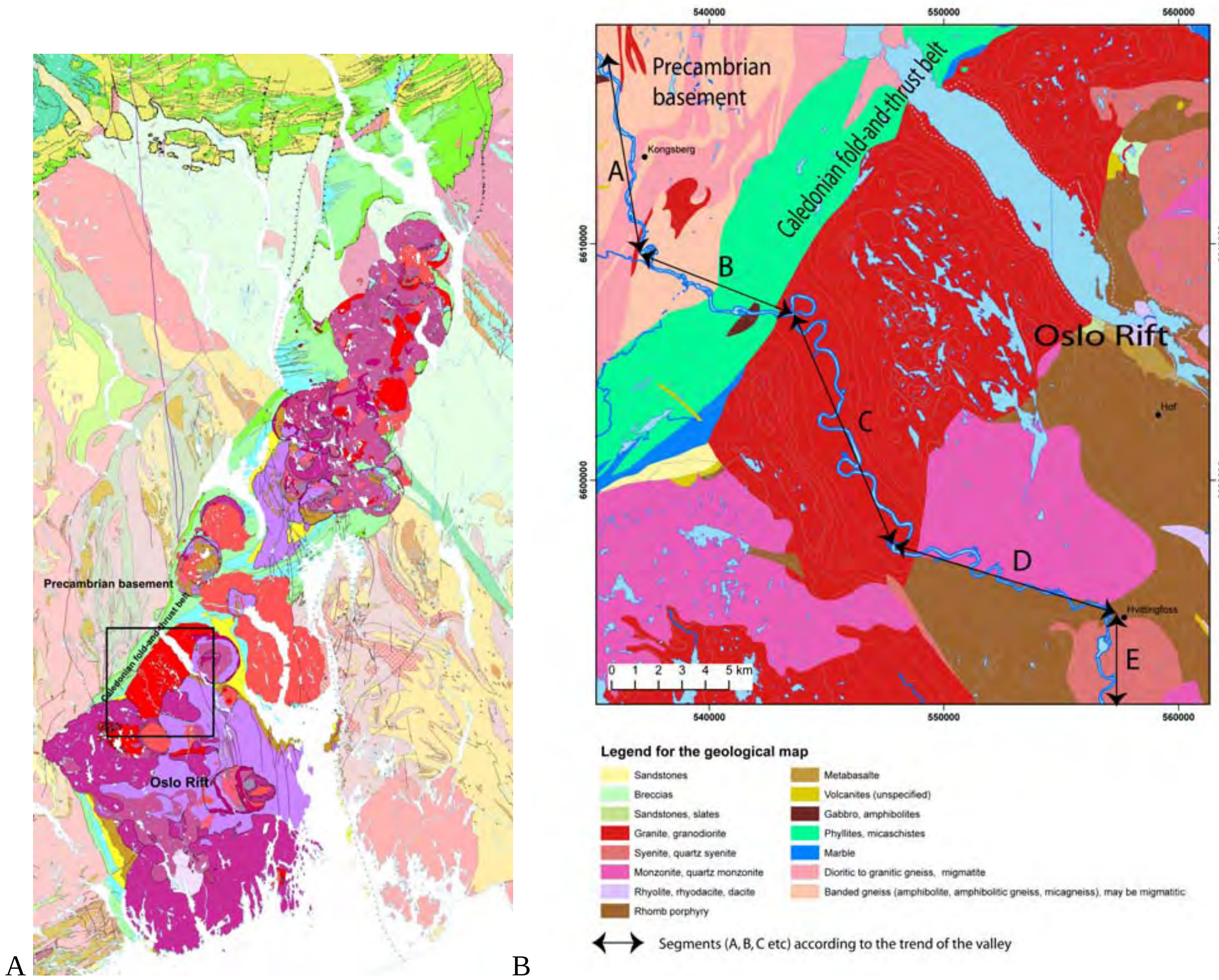


Figure 1. A, Geological map of Oslo Rift region (digital database ngu.no). The studied area is limited by the black square. It straddles the contacts of three main units: Precambrian basement, Caledonian sedimentary fold-and-thrust belt and Oslo rift magmatics. B, Geological map of the Numedalen valley from Kongsberg to Hvittingfoss. Different segments of the valley are indicated with arrows A to E.

Maps and profiles of electric resistivity have been acquired along the Numedalen valley by SkyTEM (2006) to constrain the thicknesses and lithology of the Quaternary unconsolidated sedimentary infill (characterised by low electric resistivity compare to the hard rocks). At a regional scale, these data are in agreement with the thickness distribution that was previously developed from gravimetric measurements (Tønnesen, 1980) showing 4 depocentres (Figure 2A and B). The greatest Quaternary sediment thicknesses are found on top of the Cambro-Silurian sedimentary rocks of the Late Caledonian fold-and-thrust belt and of the granitic massif. The contacts between these three tectonic units are marked by a significant decrease of sedimentary thickness (Figure 2A and B). The bedrock geology thus significantly controls the spatial distribution of the youngest Quaternary sedimentary sequences along the valley. The mean resistivity maps at several depths down to 140m (an example of one slide at 20-40 m.b.s.l., Figure 2B) allowed the refinement of the previous map (Figure 2A) by displaying a shift in the two depocentres (in blue on map of Figure 2B) of the sedimentary infill along the NW-SE axis of segment C of the valley (cf. Figure 1B).

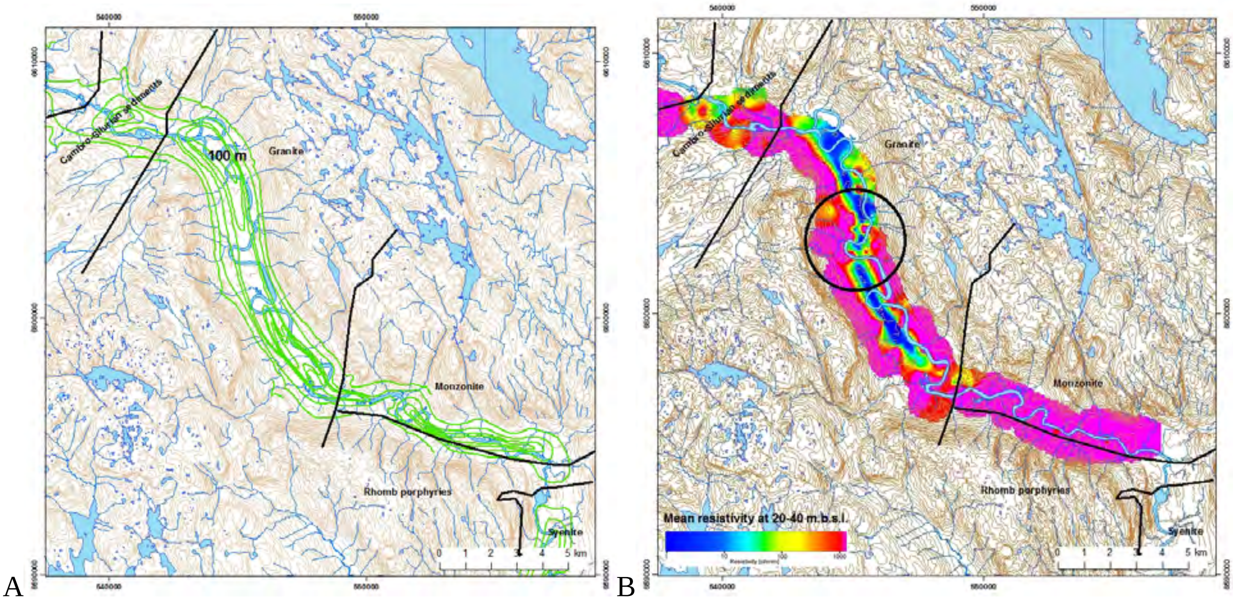


Figure 2. A. Control of the thicknesses of unconsolidated Quaternary sediments (in green) along the valley by the NE-SW trending lithological contacts (black lines). Maximum thickness over 100 m is observed (map by courtesy of Hans De Beer). B. Mean resistivity map at 20-40 m.b.s.l. showing, along the NW-SE trend of the valley, the shift between the two sedimentary depocentres lying on the granitic part, with, in black circle, the zone where the shift is located.

2 BRITTLE TECTONICS AND ITS RELEVANCE FOR THE HYDROGEOLOGY OF NUMEDALEN VALLEY

This chapter firstly reviews the importance of studying structural geology to establish a proper hydrogeological model of a given region, and secondly, describes the results of structural and field studies conducted the 25-26 May and 4-7 October 2005. The geological maps Kongsberg and Siljan at the scale 1/ 50 000 (Nilsen and Siedlecka, 2003; Holm and Larsen, 1997) were used in the field.

2.1 Hydraulic properties of brittle structures and their role in hydrogeological systems

First of all, in the studied area, one can consider that the investigated rocks have a very low to not exciting porosity, with a very low intrinsic permeability: the bedrocks are crystalline (metamorphic Precambrian basement and magmatics of the Oslo rift units) or buried sediments (the Late Caledonian succession). In such bedrocks, the effective porosity can only be due to the a secondary porosity created by fracturing (or fracture porosity). Also, it is common that, in such geological settings, the main groundwater flow should be heterogeneous, anisotropic and guided by specific fractures (Neretnieks, 1985) including fault zones, dykes, and lithological contacts. Accordingly, one of the main issues in the present study will be to define such structures and to estimate their hydrodynamic parameters (and more specifically to estimate their permeability relatively to the host rocks).

Commonly fault zones can be divided into a series of distinctive constituent elements (Figure 3). These are 1) the undeformed host rock, 2) the damage zone and 3) the fault core (Sibson, 1977 and e.g. Caine et al., 1996, Evans et al., 1997, Gudmundsson et al., 2001). The host rock consists of undisturbed rock. The damage zone is characterised by a high fracture frequency with, typically, the fractures parallel to the fault being the greater and most frequent (Figure 3). Narrow zones or bands of fault rock may occur, especially closer to the transition to the fault core. The width of the damage zone varies with the size of the fault zone and the style of deformation, and can range from a few meters to tens of meters. The fault core is identified by the occurrence of fault rocks (Sibson, 1977 and e.g. Caine et al., 1996, Gudmundsson et al., 2001, Braathen et al., 2004). Fault rocks may occur in lenses alternating with pods of relatively undeformed rock, and may be composed of several types with very different lithology and texture (i.e. pseudotachylytes can coexist with breccias; e.g. Braathen et al., 2004; Figure 3). The width of the fault core may vary from cm to m. Even if the definition of fault zone given above is the most accepted and used among geologists, one can mention that other definitions of fault zones exist. For example and as an end-of-scale definition, Munier et al. (2003) defined a fault zone using fracture frequencies with (1) a fault core characterized by intensively fractured rock, with more than 9 fractures/m, (2) the host rock, with a low fracture frequency of less than 4 fractures/m and (3) a transition zone, lying in between the two other components, and with an intermediate fracture frequency.

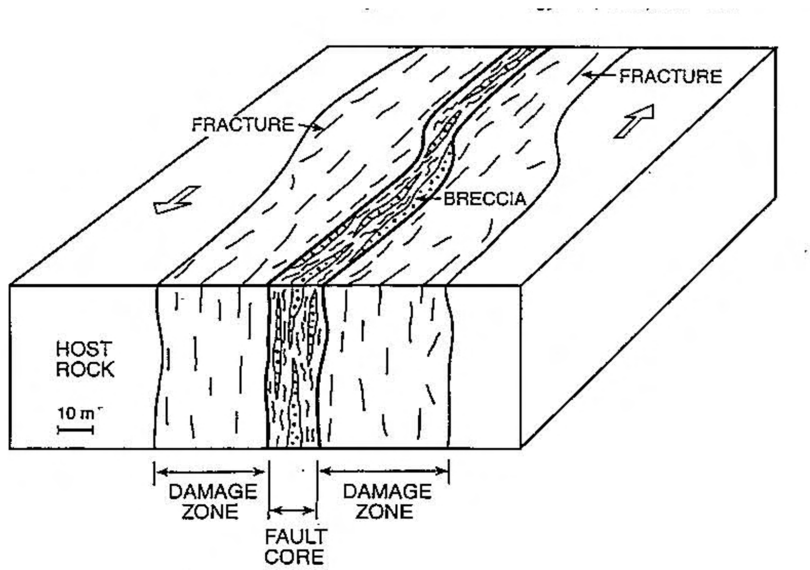


Figure 3. Schematic illustration of the architecture of an idealized fault zone (from Gudmundsson et al. 2001). Note (1) the different fault rock lithologies and structures in the fault core and (2) the only occurrence of large fractures parallel to the fault in the damage zone whereas many other sets of fractures may be present.

Following the classical definition of a fault zone (Figure 3), the permeability of a fault zone is controlled by the permeability of the two fault components, i.e. the fault core and the damage zone (Caine et al., 1996; Evans et al., 1997). The permeability of the damage zone is dominated by the hydraulic properties of the fractures (aperture, connectivity), and the permeability of the fault core, by the grain-scale permeability of the fault rocks (depending thus of its lithology). In the case of clay-rich or cohesive fault rock infill, the fault core acts as a barrier for fluid flow (Evans et al. 1997). Then, the fluid flow in the fault zone is (1) mainly in the damage zone, with, according to laboratory tests, an intrinsic permeability 10^4 times greater than the permeability of the crystalline host rocks and the fault core; Evans et al. 1997) and (2) anisotropic along the main set of large joints parallel to the fault trend. In this way, some large fault zones have permeability to be aquifers. The scheme of Figure 4 (Caine et al., 1996) well summarizes the concept of fluid flow along a fault zone whose two constituents, an impermeable fault core and a permeable damage zone, vary in

width. At the scale of the outcrops, it is common to observed single striated fault planes that are the localized conduit in the scheme of the Figure 4.
In addition to the concept for fault types of Figure 4, one should be aware that the fault rocks are very various in types and can be uncemented (as predicted by Braathen et al. 2004: if the deformation is highly due to frictional flow, non-cohesive fault rocks develop). If the fault rocks are uncemented (or non-cohesive), the whole fault zone (core and damage zone) will be more permeable than the host rocks. This is also what is expected for the permeability of a so-called crushed zone, which is an actual fault zone composed by a unique component: a fine- to medium-grained uncemented brecciated fault core. A crushed zone will therefore act as a conduit.

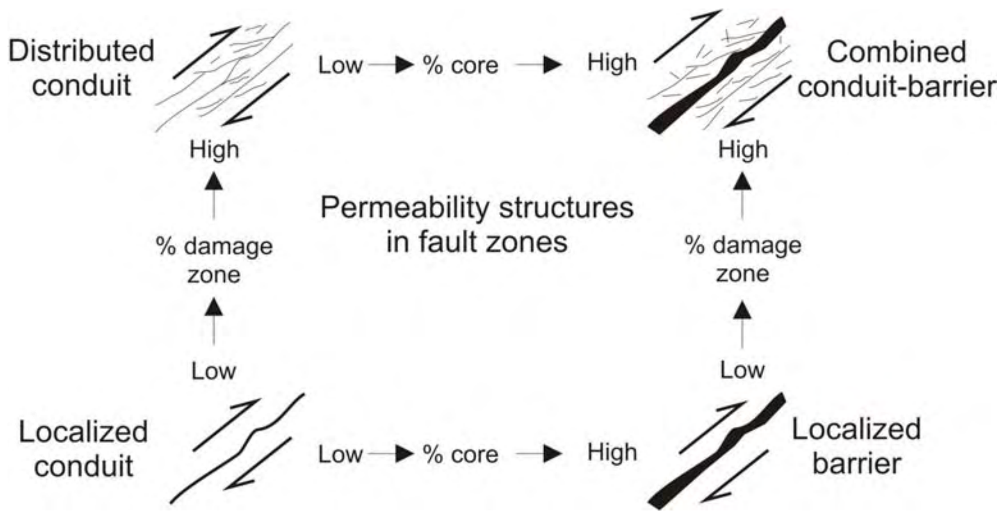


Figure 4. Conceptual scheme for fault-related fluid flow (in Caine et al., 1996).

The aperture of fractures and the connectivity of fracture network in the host rocks

To allow the fluid flow along a single fracture, it should be open, but unfortunately, and this is a limitation in the field observations, the aperture of joints is not always visible to the naked eye. Also, in the case one can observe aperture of fractures on an outcrop, it does not mean that the fractures will still be water-conductive at depth because of the effect of confining pressure that tends to close the fractures. However, this is at around 500 m depth and further down that the closure of fractures becomes very effective (e.g. in Evans et al., 1997). In Norway, the water table generally lies at shallower depth (well above 500 m depth) so one can assume that the fractures are still open at this depth and like at the surface.
Another assumption of importance is that the fractures should be connected to form a network through which the water can percolate. The determination of the connectivity of a fracture network is fundamentally dependant of the scale of observation as well demonstrated by Odling (1997). At small-scale of observation, the connectivity of fractures always appears to be lower than in reality (and this is called the apparent connectivity). In turn, at the scale of the outcrops, it is very common to identify two or three set of fractures (and mostly joints) that cross each other.
If in the host rock, the fracture frequency is as defined by Munier et al. (2003) of less than 4 fractures /m, it is unlikely that connectivity occurs and the rock volume stays impermeable. However, at many places visited during the field campaign in the host rocks, the fracture frequency is greater than this threshold value given by Munier et al. (2003) and discussion of the possible connectivity of fractures and thus percolation through fractures should be assessed. Finally, one can keep in mind that the fracture density (and thus connectivity of network) tends to dramatically

decrease with depth and the bulk permeability of the host rock declines faster than the permeability along a fault zone (e.g. Evans et al., 1997; Jones et al. 1999).

The micro-fracturing of rocks

The purpose of micro-fracturing analysis is twofold. First is to compare the micro-fractures with the fractures at the scale of the outcrops (frequency, mineral infill). Second is to estimate the hydraulic properties of the micro-fractures and their relevance at the scale of the regional study. If many open micro-fractures are observed this can increase the porosity of the system (in term of secondary fracture porosity) and may influence the storage capacity of the bedrock and the water percolation through the rocks. However, it will normally in crystalline rocks, be of minor importance for the water flow compared to large open fractured discontinuities.

2.2 Brief overview of the visited sites

36 sites (Figure 5) were visited in order to characterise (1) the structural geology of the valley and the large brittle structures and (2) the role of brittle structures in the hydrogeological system with mainly, a qualitative estimation of their permeability. The field study focused on brittle tectonics. More than one thousand planar structures were measured. All measurements and comments on structures are listed by sites in Appendix A. Also, a few rock samples were collected and thin sections made in order to characterize the fractures at the microscopic scale. Samples were specifically taken where highly fractured mafic dykes were observed in a less fractured host rocks. Samples are listed in Appendix B. Field observations were made in geographically distinct zones and will be presented according to their location in the following paragraph 2.4.

2.3 First and second order discontinuities of Numedalen valley

2.3.1 Linear features and lineaments

A simple way to gather information on regional structural trends is to extract linear features from satellite imagery and aerial orthophotos (available from www.norgeibilder.no) together with the spatial analyses of subsequent streams of the surficial drainage network (Figure 6). Some lineaments are also extracted that may represent regional geological discontinuities. The consistent arrangement of linear features over a long distance may also reveal lineaments.

The rose diagram of all the trends of linear features extracted with such methods shows 4 distinct peaks (Figure 7). The two major sets are NW-SE and N-S striking sets, with an also well expressed NE-SW set. Finally, a minor E-W trend was also found.

In the granitic massif (see the map of Figure 5), two trends of linear features coexist: a NW-SE trend that is the largest and the best expressed but also a secondary NE-SW trend (Figure 6). Moving to the south-east, within the monzonite, syenite and rhomb-porphyry massifs (cf. on map Figure 5), a large N-S trend in addition to the main NW-SE trend is present (Figure 6). Even if more discrete, these two trends are observed in the Precambrian rocks north-westward together with an E-W and a NE-SW trends (Figure 6). The NE-SW large lines parallel to the contacts between the Caledonian sedimentary fold-and thrust belt and the Precambrian unit northward and the Permian granites southwards (cf. on map Figure 5) are characteristic for the whole fold-and thrust belt (Figure 6).

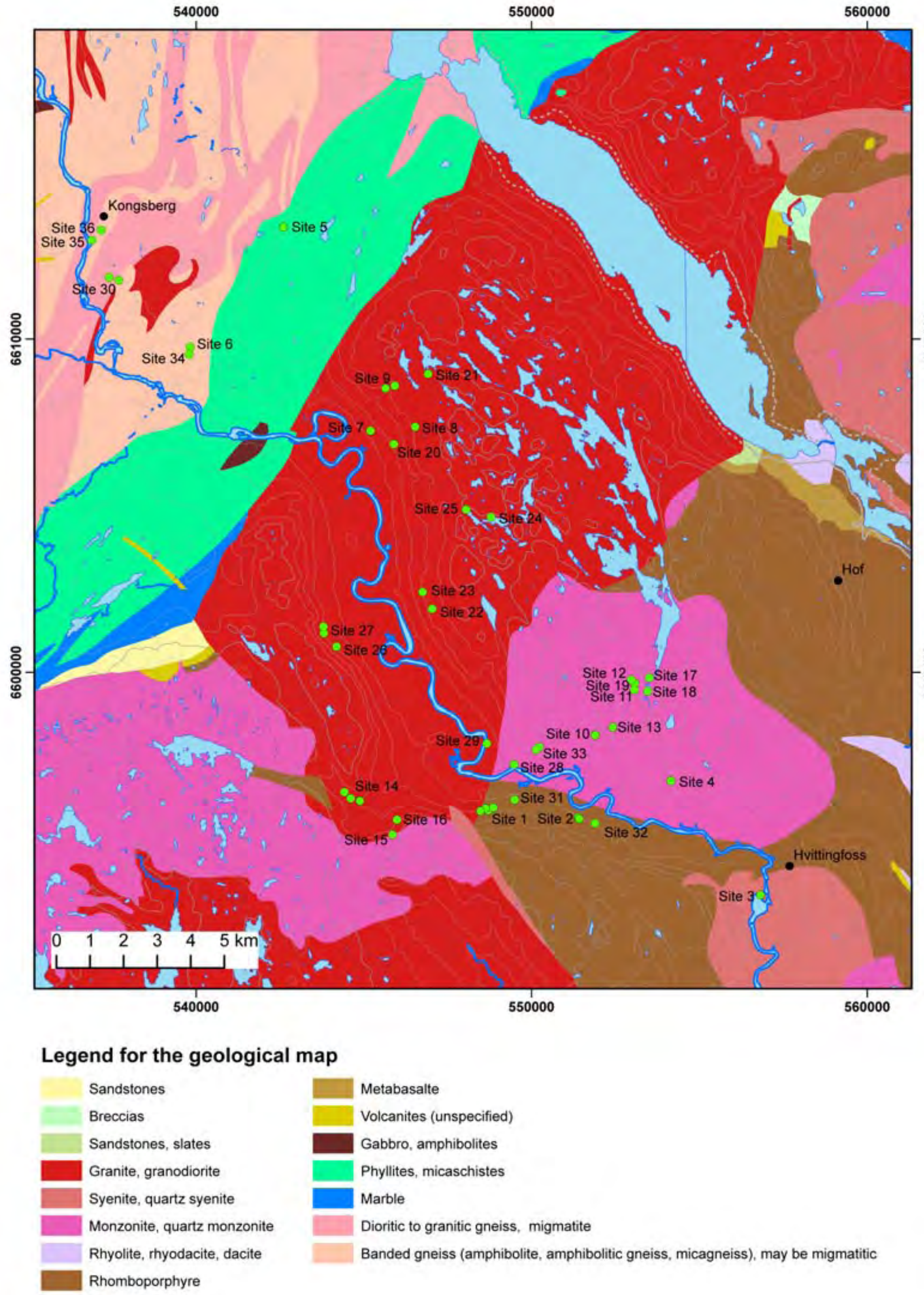
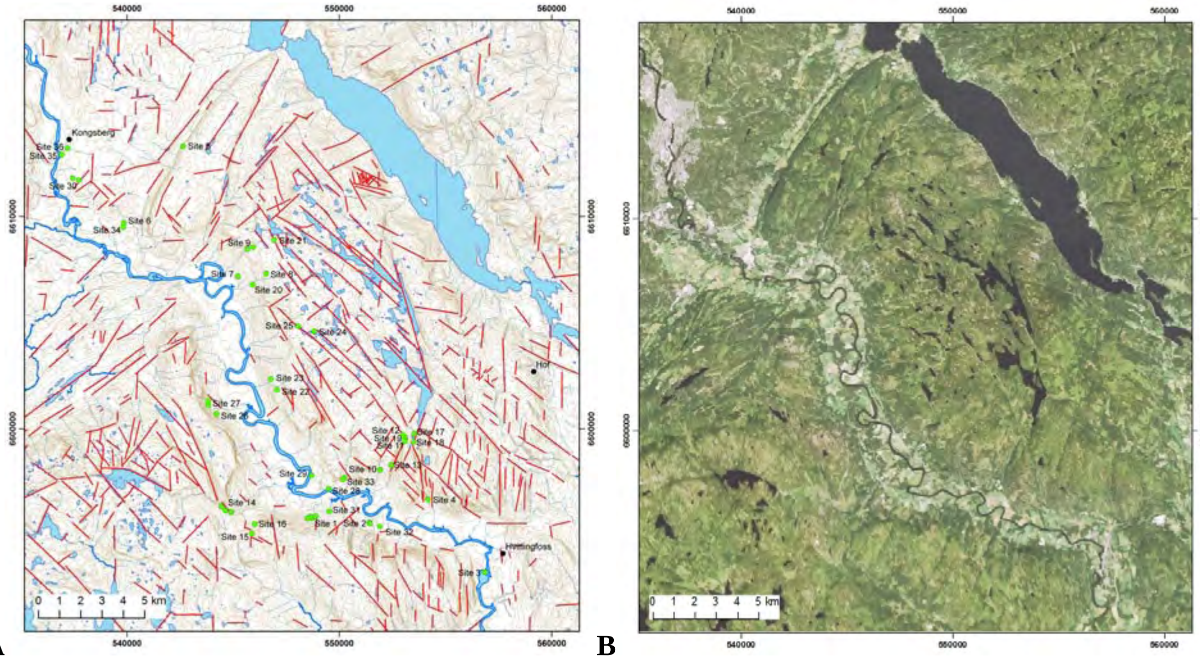


Figure 5. Locations of visited field sites. The geological map of Skien (scale 1:250000) as background. (Note: the map at 1/250000 does not display the petrographic complexity of the magmatic massifs. For example, sites 4, 10, 11, 12, 13, 17, 18, 28, 33 are all on the numerous syenitic lenses present in the monzonite massifs. The different magmatic rocks are on the geological maps at 1 /50 000 used in the field).



A B

Figure 6. Linear features and lineaments (red lines on A) extracted from satellite imagery (B) and orthophotos and from the spatial analyses of subsequent streams of the surficial drainage network (from topographic map at 1/50 000 scale, background of A).

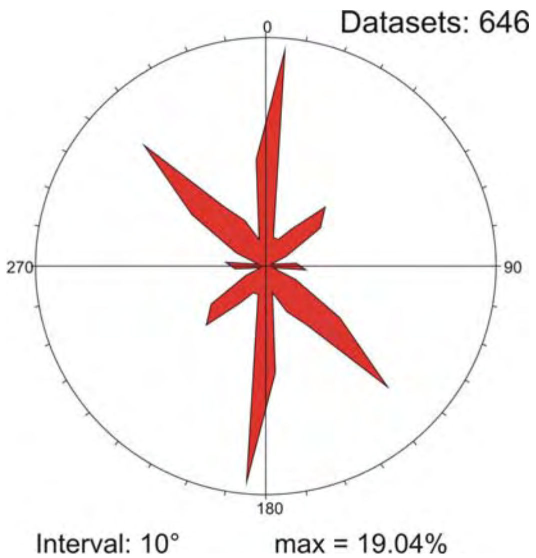
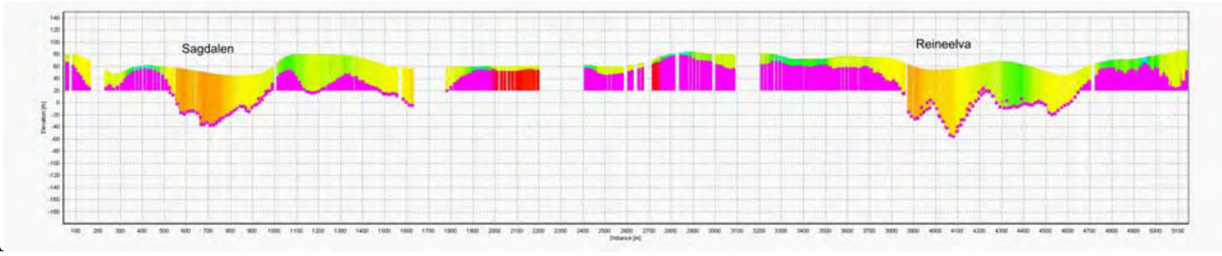
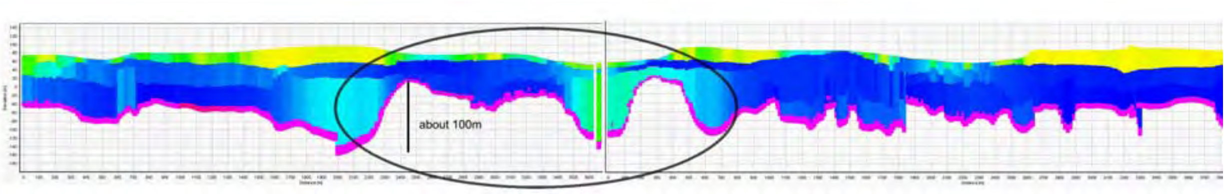


Figure 7. Rose diagram of all linear features extracted from satellite image and orthophotos and from the subsequent streams of the drainage network (see on Figure 6)

SkyTEM surveys (2006) provided electric resistivity profiles along the valley that show transverse features marked by a significant increase of sedimentary thicknesses (that are characterised by low resistivity at greater depth). This is remarkable along the profile along segment D (cf. Figure 1B) in the prolongation of the lineaments of the Reineelva and Sagdalen rivers, trending respectively NE-SW and N-S. The rivers are structurally controlled and deeply incised into the basement with strong erosion of the structures (Figure 8A). The NW-SE orientated resistivity profiles (Figure 8B) along segment C of the Numedalen valley (cf. Figure 1B) also show an abrupt and significant variation of the elevation of the granite top surface at the exact location where a shift of the NW-SE axis of the sedimentary depocentres can be observed (see the black circle in Figure 2B). Such abrupt and large elevation (of some 100 m) of the granitic top surface (in the black circle in Figure 8B) resembles a structural high. The NE-SW large lineaments that characterise the granitic massif and cross the valley are indeed very good candidates to explain this geometry and to have controlled the development of such structural high.



A



B

Figure 8. A. Resistivity profile along segment D (cf. Figure 1B) of the Numedalen valley. The two rivers Sagdalen and Reineelva have incised the bedrocks, probably along weak zones of large discontinuities B. Resistivity profile along segment C (cf. Figure 1B) of the Numedalen valley. In black circle, abrupt and important elevation of the top surface of the granitic bedrock that resembles to a structural high. Highest resistivity values in pink-red are interpreted to be the top surface of the magmatic bedrocks, lowest resistivity values in orange-yellow-green are interpreted to be the Quaternary sediments (SkyTEM, 2006).

2.3.2 Comparison of the trends of first and second order discontinuities

The rose diagram of Figure 9 gives an overview of the main direction and dip angle of the planar structures measured in the field (as second order discontinuities). Similarity between the directions of discontinuities at different scale makes it possible to deduce the nature of first order discontinuities using observations at the scale of the outcrops (i.e. the second order discontinuities).

The predominant NW-SE trend (Figure 9) is parallel to one of the largest sets of first order discontinuities (i.e. linear features and lineaments; cf. paragraph 2.3.1, Figure 6 and Figure 7). The main set of N005 first order discontinuities and, to some extent the E-W and NE-SW first order discontinuities, are also well represented at the scale of the outcrop. However, the predominant set of the second order discontinuities strikes around N020 and does not correspond to a large set of the first order discontinuities (8 % of the total amount, see rose diagram of Figure 7).

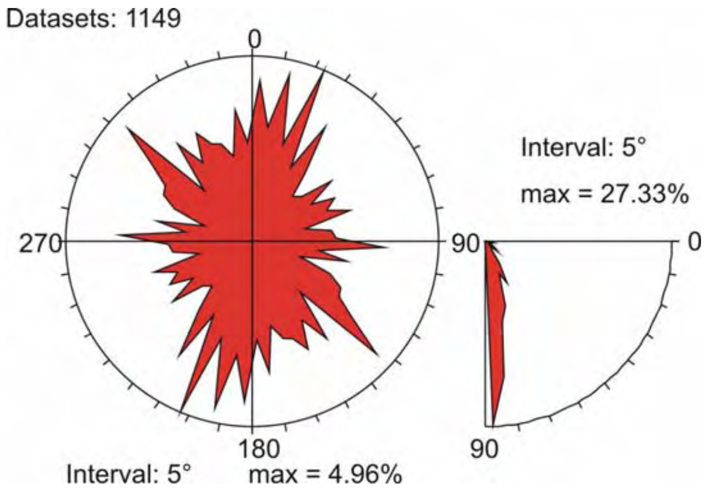


Figure 9. Rose diagram of direction and dip angle of the planar structures collected in the field (i.e. second order discontinuities).

2.4 Detailed analyses of brittle tectonics by sub-areas along the Numedalen valley and estimated hydraulic properties of structures and their influence for hydrogeology

In the following paragraphs, details of structural field studies are presented together with photo documentation and from northwest to southwest by sub-areas along the Numedalen valley: in the Kongsberg area (sites 30, 35 and 36, paragraph 2.4.1), from Skollenborg to Hassel (sites 5, 6 and 34, paragraph 2.4.2), in the surrounding of Jartkjær lake (sites 7, 8, 9, 20 and 21, paragraph 2.4.3) and of Damvanna lake (sites 24 and 25, paragraph 2.4.4), in Sauar- Lindum area (sites 22, 23, 26 and 27, paragraph 2.4.5), along the Støleelva river (sites 14, 15 and 16, paragraph 2.4.6), in Rud-Gran-Ånnestad area (sites 1, 2, 28, 29, 31, 32 and 33, paragraph 2.4.7), along the Sagdalen valley (sites 10, 11, 12, 13 and 19, paragraph 2.4.8), along the Svartebekk river (sites 17 and 18, paragraph 2.4.9) and the Reineelva river (site 4, paragraph 2.4.10), and in Hvittingfoss area (site 3, paragraph 2.4.11). The detailed analysis of brittle tectonics by sub-areas along the Numedalen valley allows characterisation of major-scale structures. An attempt is made to estimate the hydraulic properties of the large brittle structures in the same given area.

Keys to read stereonets in the following paragraphs

At the scale of the outcrops, a systematic analysis of brittle structures was made. It includes the analyses of fault slip data, which comprises an analysis of strikes and dips of fault sets and pitch of their striae. It allows the characterisation of the kinematics of fault trends (even major fault trends). Figure 10 give the keys for reading stereonets of fault slip data sets. The other brittle structures were also taken into account and plotted as such: undistinguished fractures/diaclases/joints in black, tension gashes in blue (only used if minerals have clearly grown into the fractures, this implies an opening of the fractures under tension), metamorphic foliation or bedding planes in green, mafic dykes/veins in purple, felsic dykes/veins in pink, crushed zones in red (Figure 11).

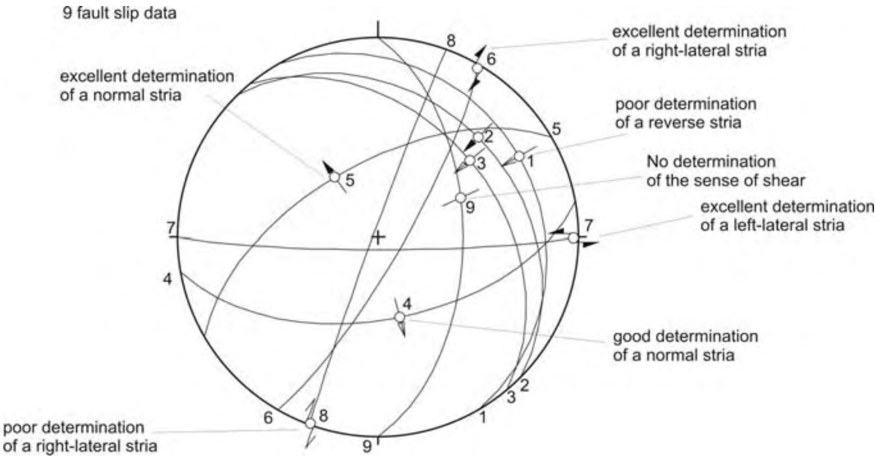


Figure 10. Example of stereonet for fault slip data, Schmidt's projection, lower hemisphere. Keys for striae: outward directed arrow: normal striae (numbers 4 and 5 on stereonet); inward directed arrow: reverse striae (numbers 1, 2 and 3); couple of arrows: strike-slip striae (numbers 6, 7 and 8); full black arrow: excellent constraints on the sense of shear (numbers 2, 5, 6 and 7); empty arrow: good constrains on the sense of shear (numbers 3 and 4); simple arrow: poor constrains on the sense of shear (numbers 1 and 8); thin line: no determination of the sense of shear (number 9).

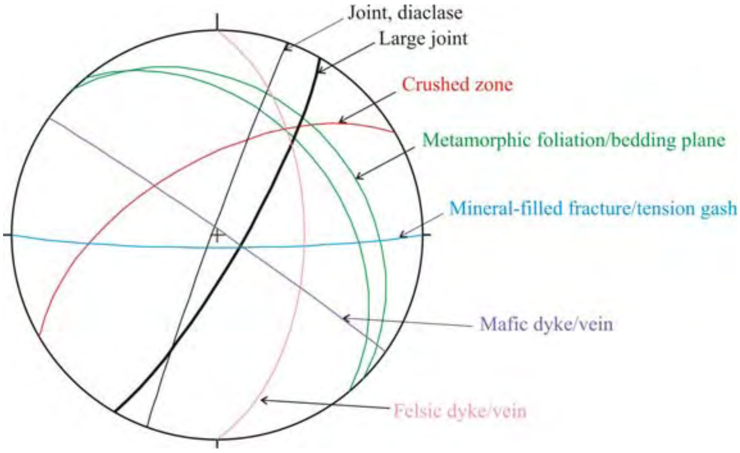


Figure 11. Example of stereonet for structures other than fault slip data, Schmidt's projection, lower hemisphere. Diaclases/joints in black, large joints in bold black, mineral-filled fractures/tension gashes in blue, mafic dykes/veins in purple, felsic dykes/veins in pink, metamorphic foliation and bedding planes in green, crushed zones in red.

2.4.1 Brittle tectonics in Kongsberg area (Gamlegrendåsen) (sites 30, 35 and 36)

The three sites of Kongsberg area are located on Precambrian rocks and stereonets of the structures observed are shown on Figure 12. Foliation trends NE-SW and steeply to moderately dips to the southeast. Mineral-filled fractures, interpreted as tension gashes, are common and trend NW-SE. At site 30, the foliation planes are reactivated as normal faults (Figure 12 and Figure 13). Both the NE-SW and NW-SE trends of first order discontinuities (i.e. the linear features on Figure 6) are then observed at the scale of the outcrops as foliation planes with foliation-parallel normal faults and tension gashes, respectively. Tensional stresses reactivated the NE-SW foliation planes and developed NW-SE tension gashes. The regional-scale structures can be also tensional structures, i.e. normal faults. However, nothing can be said to better characterise the width, the infill of these regional-scale structures and therefore, their hydraulic properties.

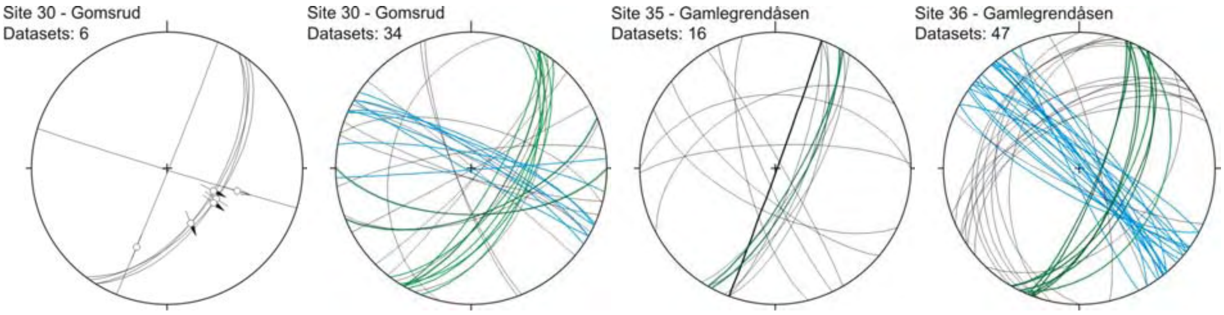


Figure 12. Stereonets of brittle structures in Precambrian basement in Kongsberg area (keys to stereonet provided in Figure 10 and Figure 11).

Figure 13. View to the east of a NE-SW east-dipping dip-slip normal fault developed along the pre-existing foliation plane at site 30 (strike and dip angle 032/59 and pitch 87N).

2.4.2 Brittle tectonics from Skollenborg to Hassel (sites 5, 6 and 34)

The stereonets of Figure 14 show the structures from three sites close to the contact between the Caledonian sedimentary fold-and-thrust belt and the Precambrian basement. In the Early Palaeozoic sedimentary succession, N-S, E-W and NE-SW joints and tension gashes are present and display a very high spatial density. In the Precambrian unit, NW-SE and NE-SW to N-S steep joints with shallow south-dipping faults and joints are observed. Some NE-SW and few NW-SE fractures display striations on their surfaces at site 6. The NE-SW first order discontinuities observed in the area (i.e. linear features on Figure 6) can be large brittle structures, and maybe faults, but more detailed characterisation of them, and specifically their role in the hydrogeological system, is not possible.

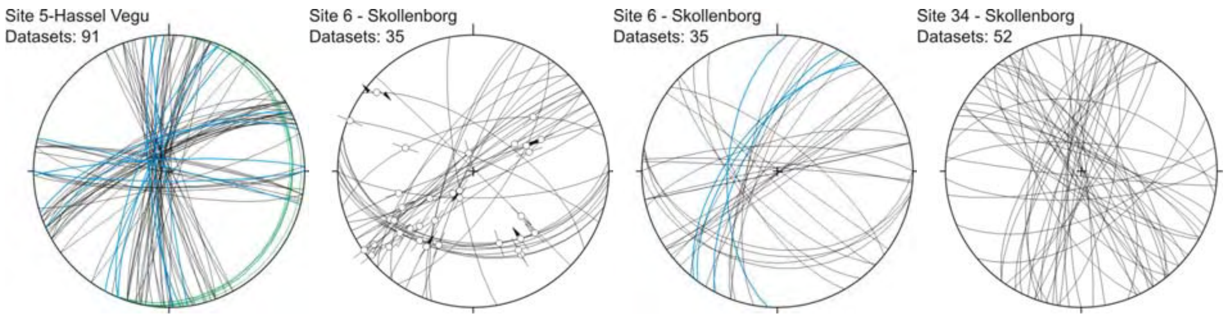


Figure 14. Stereonets of brittle structures in the region close to the contact between the Precambrian mafic basement (sites 6 and 34) and the sedimentary Caledonian fold-and-thrust belt (site 5) (keys to stereonet provided in Figure 10 and Figure 11).

2.4.3 Brittle tectonics in the surrounding of Jartkjær lake (sites 7, 8, 9, 20 and 21)

Figure 15 shows the stereonets of brittle structures developed in the granitic massif to the west of Jartkjær lake. The brittle tectonics in the area is mainly expressed by N-S and E-W steep joints and by very shallow-dipping N-S to E-W dipping joints (Figure 15 and example on Figure 16). It is only at site 21 that a N140-N150 crushed zone with a dip-slip striated plane at its border was observed. The first order discontinuities that were extracted from this area are NW-SE lineaments (see Figure 6). The NW-SE lineaments are fault zones. Also, the density of joints increases from the site 7 to the site 21 where it is very high (Figure 17). Site 21 obviously lies in the damage zone of such a NW-SE fault. The NW-SE highly fractured fault zone can be a good permeable conduit to groundwater.

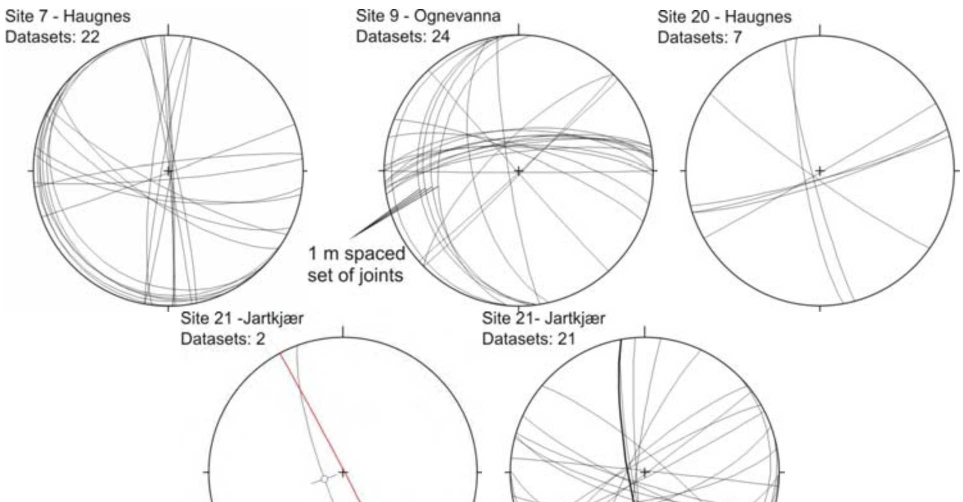


Figure 15. Stereonets of brittle structures in Permian granite in the area of Jartkjær lake, eastern side of the Numedalen valley (keys to stereonet provided in Figure 10 and Figure 11).

Figure 16. Example of shallow west-dipping joints, 1 m spaced, and large steep E-W trending joints (the front side of the outcrop) (site 9).

Figure 17. High density of joints at site 21, with both flat lying and steep joints. N-S (the wall on the picture) and NE-SW to ENE-WSW are the predominant trends of the large steep joints.

2.4.4 Brittle tectonics in the surrounding of Damvanna lake (sites 24 and 25)

At Damvanna lake on the Permian granite and at the scale of the outcrops, steep NE-SW and E-W trending brittle structures are predominant (Figure 18). At site 24, the E-W trending structures are oblique normal faults and tension gashes. At site 25, NNE-SSW major oblique normal faults and NE-SW mafic dykes are present (Figure 19). They are most probably all related to a single event of brittle tectonics and developed under a NW-SE tensional stress field.

No difference of joint density is observable between mafic rocks (present as intrusions and enclaves) and the host granite (Figure 19). Sampling was made of the granitic host rocks at both sites (samples 1 and 3, Appendix B) and of the mafics at site 25 in order to characterise the micro-fractures, if any (samples 2 and 4, Appendix B). The two thin sections of granite display totally filled patches of a secondary mineral (prehnite). At site 25, the thin sections of a mafic inclusion (sample 2) and of a 3 m wide NE-SW mafic dyke (Figure 19, sample 4) do not show any fractures. No open micro-fractures may thus contribute to an increase of permeability in the area.

Damvanna lake is in an area of mainly NW-SE and some NE-SW linear features at the regional scale (see Figure 6). The NE-SW set may correspond to large tensile structures like faults and dyke-infilled dilatant zones. From Damvanna lake, such a large NE-SW fault crosses an area where the electric resistivity survey (Figure 2B and Figure 8B) revealed a structural high with the abrupt variation of the elevation of the granite top surface. This confirms that a NE-SW large fault zone might be invoked to explain the formation of the structural high along the Numedalen valley. However, there are no direct field observations (like a high joint density, or uncemented fault-rock occurrence) to infer for an increase of permeability along these large NE-SW structures.

Little can be deduced from the field analyses on the nature of the NW-SE first order discontinuities as only some joints and mineral-filled fractures are observed at both sites 24 and 25.

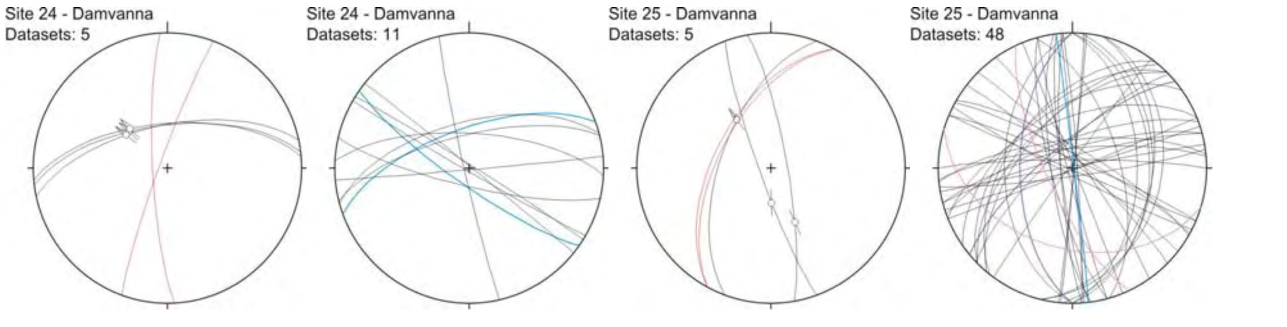


Figure 18. Stereonets of brittle structures in Permian granite in the area of Damvanna lake (keys to stereonet provided in Figure 10 and Figure 11).

Figure 19. Left: NNE-SSW normal fault at site 25 (strike and dip angle N208/58); Right: 3 m wide basaltic dyke (strike and dip angle N230/75, sample 4 listed in Appendix B) cutting across the granite at site 25; no difference in joint density can be observed between the two lithologies (10 years old boy for scale).

2.4.5 Brittle tectonics in Sauar- Lindum area (sites 22, 23, 26 and 27)

The sites described herein are on the Permian granitic massif (along segment C of the Numedalen valley on Figure 1B). As the sites are on each side of the valley, the comparison of their brittle tectonic record may provide useful information of the bedrock structure at the bottom of the sediment-filled valley.

Roughly trending NW-SE and NE-SW structures are present on both sides of the valley (Figure 20 and Figure 21). Some of the NW-SE structures are mineral-filled tension gashes. NE-SW normal faults are observed at site 22. A large set of N115 striking faults displaying oblique striae is present at site 27. N-S trending joints seem more developed on the western side of the valley.

Few first order discontinuities were extracted in the vicinity of the Sauar-Lindum area (see Figure 6). The NE-SW and NW-SE trends of first order discontinuities seen in the surrounding granitic massifs (and described in the previous paragraph) are, however, well present in the structures cropping out in Sauar-Lindum area. Also, the sites are very close to the structure revealed by the mean resistivity maps and profile (Figure 2B and Figure 8B) and that offsets the axis of Quaternary sedimentary depocentres. The amount of NE-SW brittle structures observed in Sauar- Lindum area may confirm the presence and the role of large NE-SW brittle features in the development of the structural high. No more detailed characterisation of the regional-scale NW-SE and NE-SW structures can be deduced by the field observations in this sub-area, specifically for their capacity to conduit groundwater.

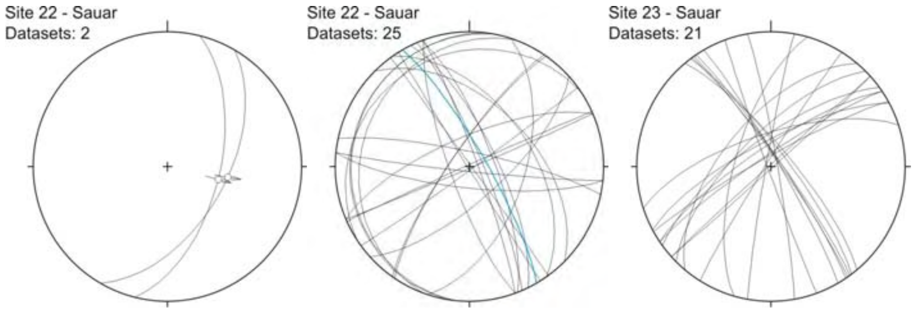


Figure 20. Stereonets of brittle structures in Permian granite in the area of Sauar, eastern side of the Numedalen valley (keys to stereonet provided in Figure 10 and Figure 11).

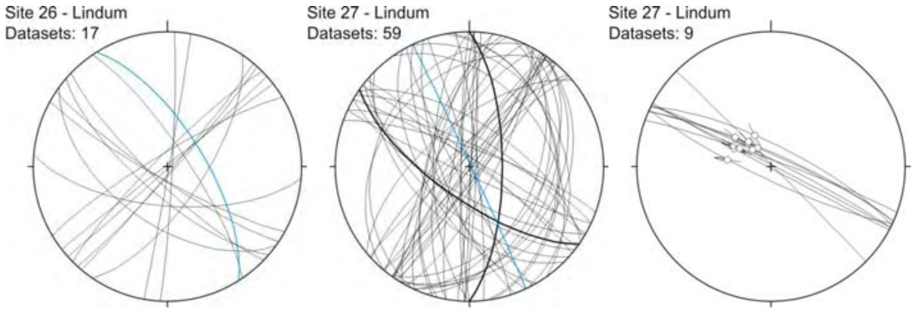


Figure 21. Stereonets of brittle structures in Permian granite in the area of Lindum, western side of the Numedalen valley (keys to stereonet provided in Figure 10 and Figure 11).

2.4.6 Brittle tectonics along the Støleelva river (sites 14, 15 and 16)

Field investigations along the Støleelva river have allowed determining different trends of fracturation from site 14 in the granite and from the two sites 15 and 16 in the syenites (Figure 22). NNW-SSE and NW-SE normal faults (Figure 23) and associated parallel joints are observed at site 14 and E-W trending crushed zones (Figure 23) with related joints and tension gashes. Few brittle structures are observed in the syenitic lens of sites 15 and 16. They are NW-SE and NNE-SSW steep joints (resembling a conjugate system of joints) and flat, west-dipping joints.

The first order discontinuities in the area are dominated by NW-SE lineaments (see Figure 6) that may be interpreted as normal faults and large joints. Even if they are not well expressed in this area, the discreet set of E-W lineaments (see Figure 7) could be also fault zones according to the observations at site 14. At the most, the E-W structures are filled with fine- to medium-grained uncemented crushed-material in this area and their permeability should be high. The field observations do not allow to conclude more for a better characterisation of the large NW-SE structures relative to their hydrogeological role.

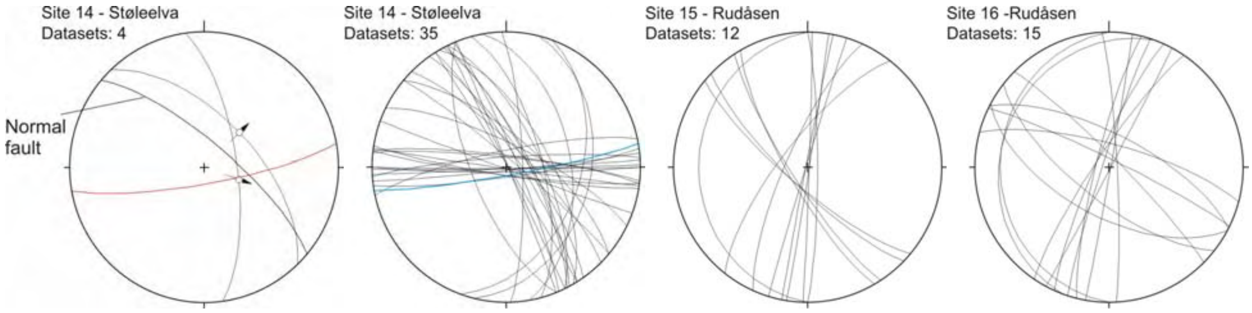


Figure 22. Stereonets of brittle structures in Permian granites (site 14) and syenites (sites 15 and 16) along Støleelva river, western side of the Numedalen valley (keys to stereonet provided in Figure 10 and Figure 11).

Figure 23. Photos of a highly fractured outcrop with E-W faults and NW-SE / NNW-SSE normal faults (site 14). The E-W faults show up to 40 c-thick crushed zone.

2.4.7 Brittle tectonics in Rud-Gran-Ånnestad area (sites 1, 2, 28, 29, 31, 32 and 33)

In Rud-Gran-Ånnestad area, the valley runs WNW-ESE and onto the contact between Permian intrusive rocks (syenites) to the north and lava flows (rhomb porphyries) to the south. Site 29 lies on the Permian granite and is located at the curve where the valley changes direction from NNW-SSE (segment C, see map of Figure 1B) to WNW-ESE (segment D, see map of Figure 1B). Sites 28 and 33 are on the northern side of the valley on the Permian syenites and sites 1, 2, 31 and 32 are on the southern side on the Permian rhomb porphyries.

On both sides of the valley, there are some E-W and many NW-SE joints, and many types of roughly N-S trending discontinuities (dykes, normal faults, tension gashes and joints, Figure 24 and Figure 25). As an example for the latter, NNE-SSW mafic dykes and a N-S striated fault are observed at site 2 (Figure 24), west-dipping normal faults at site 28 (Figure 25). At site 29, NNE-SSW faults (with an example on Figure 26) and quartz-filled tension gashes coexist with, and besides the NW-SE joints, NW-SE dykes and faults. Singular flat-lying joints are abundant into the rhomb porphyries (Figure 24).

The two main N-S and NW-SE sets are well expressed first order discontinuities (Figure 6) and may correspond for the first trend to large dykes and normal faults and for the second trend to large dykes. The abundance of the roughly N-S trending brittle structures lets presume that the regional scale N-S structures are large fracture zones. If so, they may be conduits for the groundwater flow.

Basalts were sampled at sites 1 (sample 1K, Appendix B) and 2 (sample 3K, Appendix B). At site 2, the basaltic sample is from a 10 cm wide N-S trending dyke intruded into the rhomb porphyries. At site 1, the basaltic body could not be defined, as the contacts to the host rock do not crop out. At site 1, a sample of syenite close to the contact with the rhomb porphyries was also collected. The thin sections of the basalts show few open or partly sealed (in sample 1K) to no fractures (sample 3 K). The syenite thin section displays in turn many open micro-fractures with a brownish halo alteration along the fracture edges.

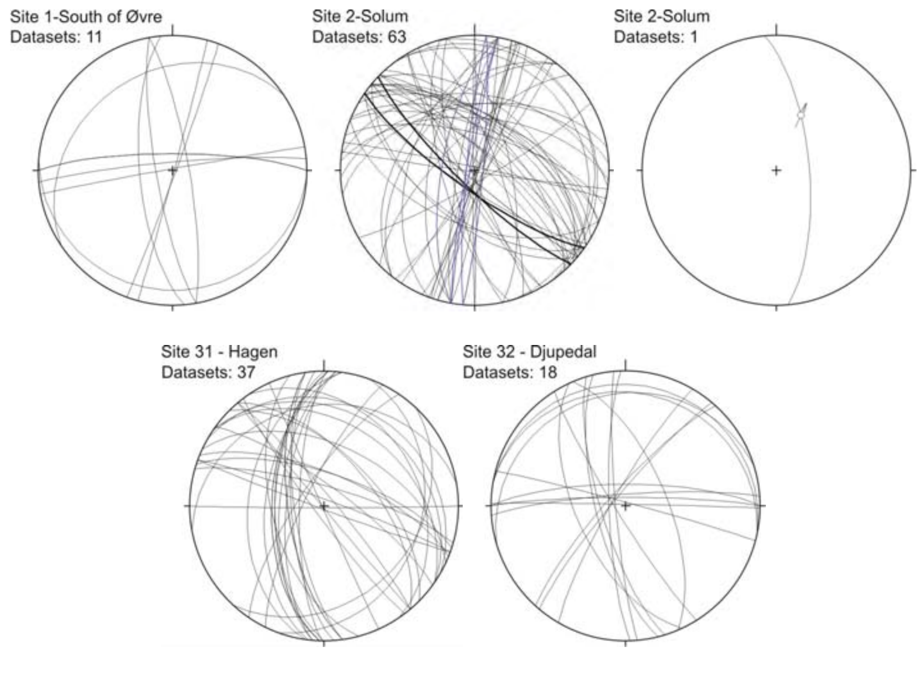


Figure 24. Stereonets of brittle structures in the Permian rhomb porphyries on the southern side of the Numedalen valley (keys to stereonet provided in Figure 10 and Figure 11).

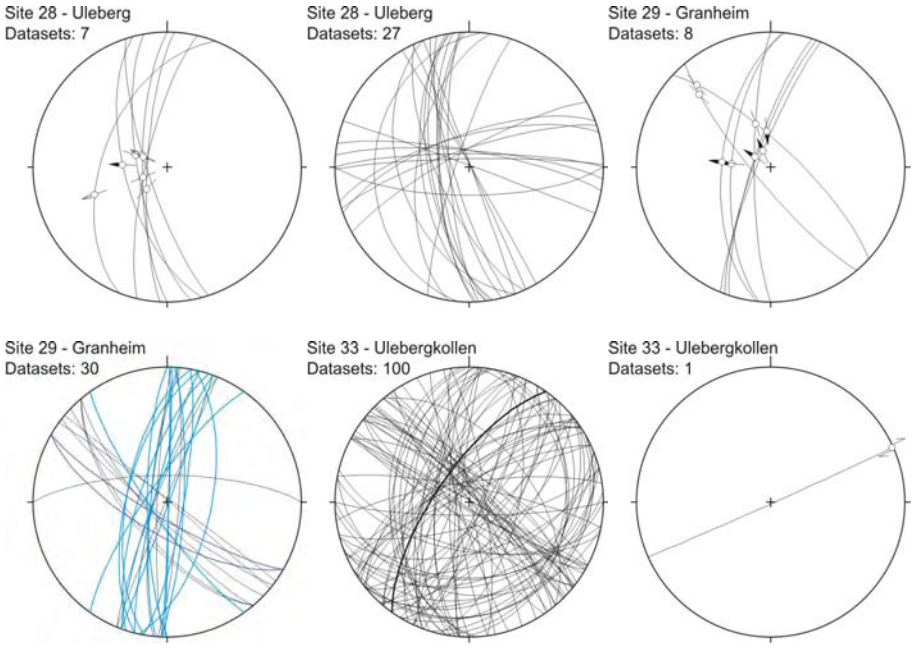


Figure 25. Stereonets of brittle structures in the Permian intrusives on the northern side of the Numedalen valley (keys to stereonet provided in Figure 10 and Figure 11).

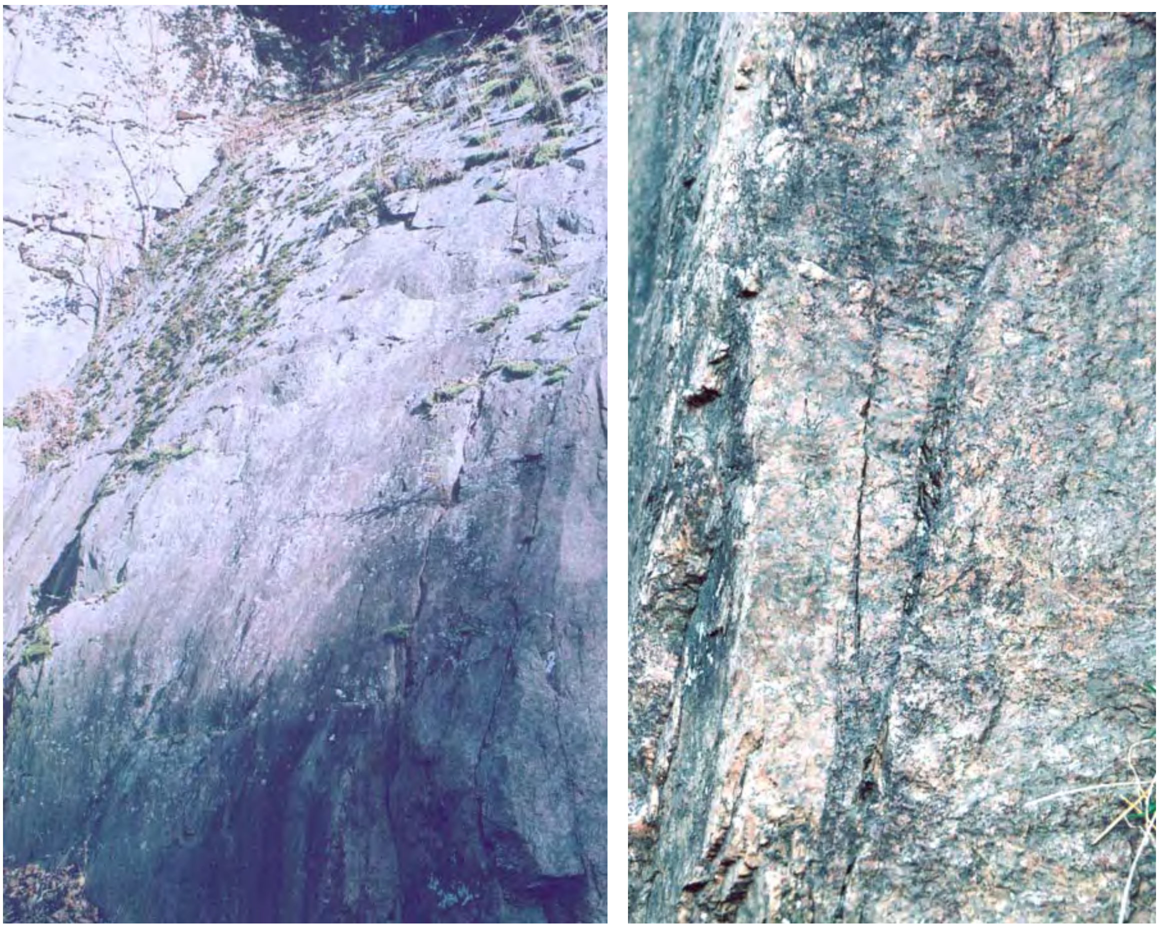


Figure 26. Left, large N185 striking dip-slip normal fault at site 29 (Granheim). Right, a side view of the fault plane, with well-developed shear fractures.

2.4.8 Brittle tectonics along the Sagdalen valley (sites 10, 11, 12, 13 and 19)

Along the NE-SW trending Sagdalen valley, it was possible to identify many NW-SE mafic dykes and tension gashes (Figure 27). At site 19, the margins of the dykes were reactivated as faults (Figure 27). At site 11, close to one of the main NW-SE lineaments (see Figure 6), the density of dykes increases up to about 5 per 10 m (Figure 28). The main NW-SE regional discontinuities are probably intrusive mafic dykes. Figure 28 also displays how the mafic dykes are more jointed (with more than 9 fractures /m) than the host syenitic rocks. Herein, it is relevant to remind that such fracture density characterised the damage part of a fault zone which is considered as permeable to highly permeable (Cf. paragraph 2.1; and so much as its fault core according to Munier et al. 2003). In this respect, the highly fracture dykes are, in this study, assumed to be water conduits.

Four of these dykes were sampled for analysis of micro-fractures in thin sections (samples 5K, 6K at site 11, 7K at site 12 and 8K at site 13; see Appendix B). The two thin sections of the highly jointed dykes at site 11 (see Figure 28) display some partly sealed quartz micro-veins in sample 5K and no fracture in sample 6K. Therefore, the permeability of the dykes may largely be controlled by the presence of the open joints and not by an additional network of permeable micro-fractures (in the hypothesis that the thin sections are well representative of the whole dyke rock). In turn, the two other thin-sections of basalts sampled at site 12 and 13 both show many open micro-fractures with a brownish alteration of the borders. Herein, the possible water circulation through the micro-fractures enlarges the permeability of the dyke.

Another predominant trend in the area is the roughly N-S trending normal to oblique normal faults that, at site 11, clearly cut across the NW-SE dykes (Figure 29). The set of N-S lineaments is particularly well expressed to the east of the Sagdalen (see Figure 6), and as mentioned in paragraph 2.4.7 above, may be related to normal faults or/and dilatant brittle structures.
From place to place, and at a few extent, some E-W faults and fractures are also observed.
Whereas NE-SW large structures are extracted from aerial photos along the Sagdalen (see Figure 6), at the scale of the outcrops, no parallel NE-SW structure is identified.

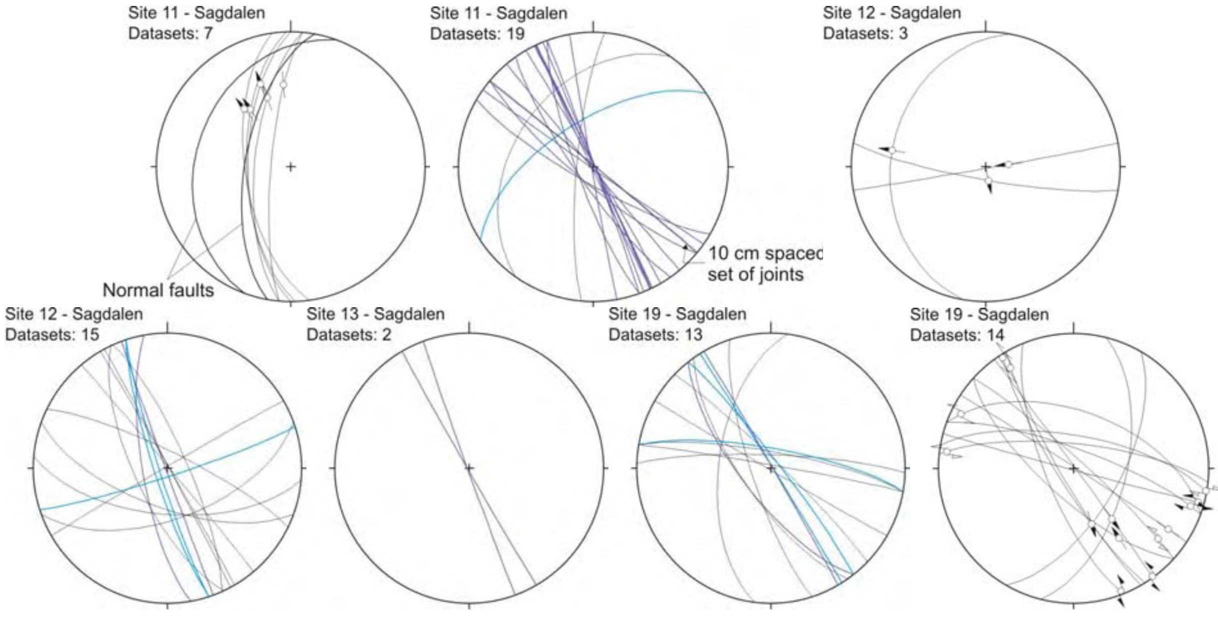


Figure 27. Stereonets of brittle structures in the Permian syenites along the Sagdalen valley (keys to stereonet provided in Figure 10 and Figure 11).

Figure 28. Example of NW-SE mafic dykes along the Sagdalen valley (site 11). Close to a large NW-SE lineament, the density of dyke increases to reach about 5 per 10 m. The picture to the right shows the high density of open joints within the dyke (compared to syenite host rock and with more than 9 fractures /m).

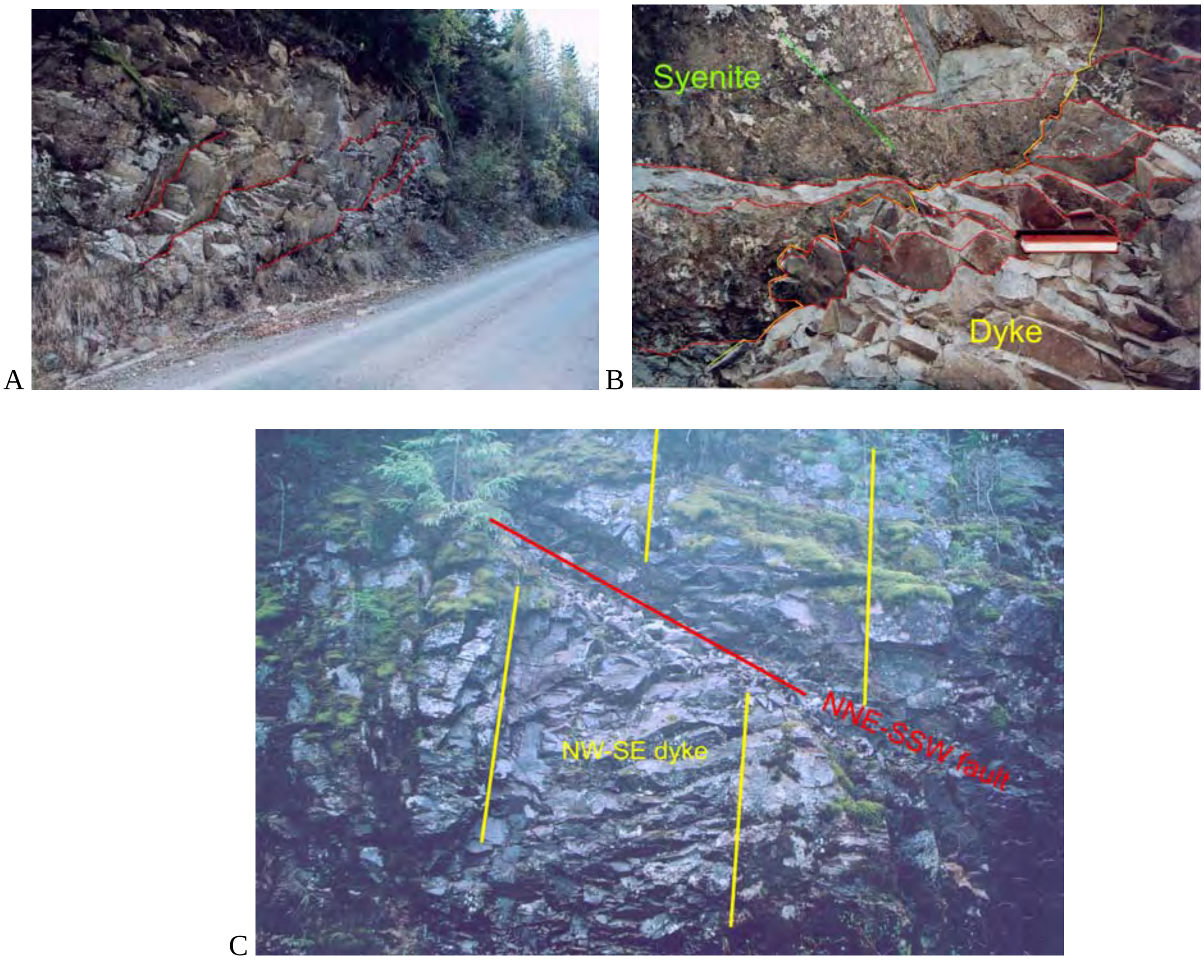


Figure 29. Examples of faults along the Sagdalen valley (site 11) A. zone of N-S west-dipping normal faults B. Attitude of the normal faults (fault surfaces are underlined in red and stria is underlined in green) at the contact between syenite and mafic dyke (underlined in yellow). The fault planes are split in several branches into the dyke. C. NNE-SSW fault offsetting a NW-SE mafic dyke of several tens of centimetres. The fault is supposed to be normal (according to the large amount of normal faults at this outcrop).

2.4.9 Brittle tectonics along the Svartebekk river (sites 17 and 18)

Along the Svartebekk river and in the Permian syenites, in addition to NW-SE joints and faults, many observations concern E-W / NE-SW structures (Figure 30) which are faults (Figure 31) and dykes. Figure 32 shows an E-W uncemented brecciated faulted border of such an E-W mafic dyke. N-S joints are observed at site 17.

The NE-SW, NW-SE and N-S trends are those of the first order discontinuities in the area (see Figure 6). Whereas along the NE-SW trending Sagdalen valley the NW-SE and N-S structures were easily identified, it was difficult to observe NE-SW brittle features (see paragraph 2.4.8 above). At the Svartebekk river, however, many of the observations may be related to the NE-SW main linear grain that may correspond to major dykes and faults. The high density of the NE-SW structures is in favour of large NE-SW damage zone along which permeability can increase. Also, and even if the E-W minor set of first order discontinuity is not well displayed in this sub-area, an E-W trending crushed zone crops out and resembles those observed along the Støleelva river (see paragraph 2.4.6). A high permeability is inferred along the crushed zone (as mentioned in paragraph 2.1).

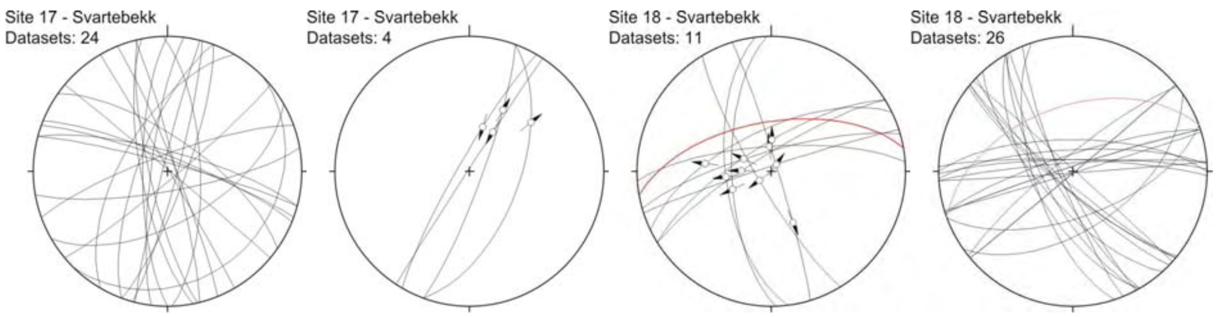


Figure 30. Stereonets of brittle structures in the Permian syenites along the Svartebekk river (keys to stereonet provided in Figure 10 and Figure 11).

A

B

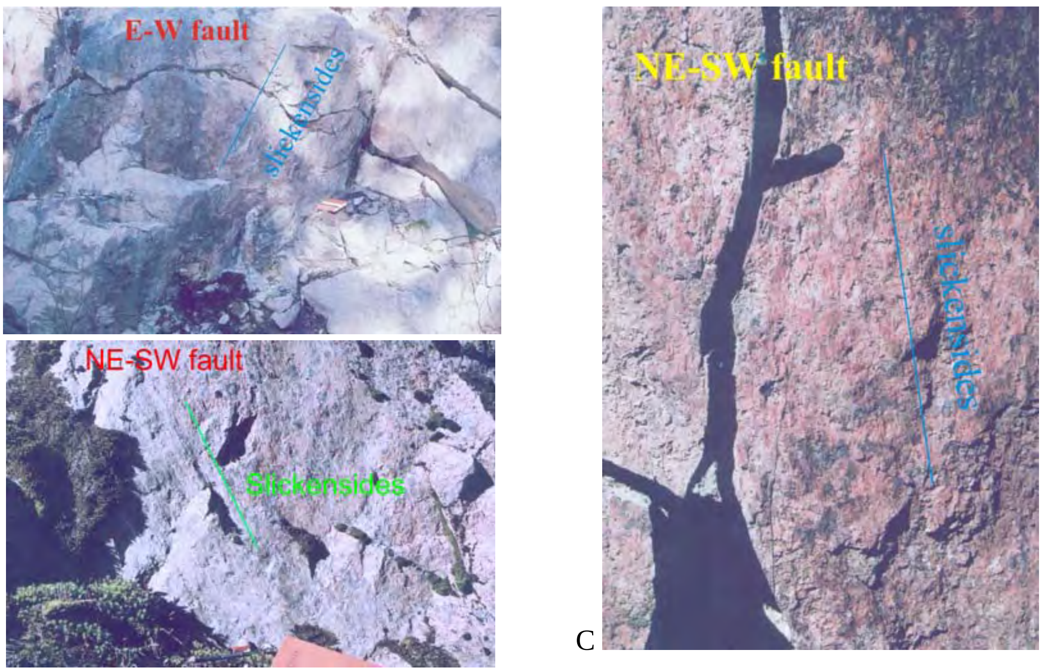


Figure 31. Examples of striated faults along the Svartebekk river. A. E-W striated normal fault (strike and dip angle 244/65 and pitch 57W) (site 18); B. NE-SW striated reverse fault (strike and dip angle 210/83 and pitch 63N) (site 17); C. NE-SW striated normal fault (strike and dip angle 238/74 and pitch 80E) (site 18).

Figure 32. E-W crushed, brecciated and striated fault (strike and dip angle 252/87 and pitch 86E) at the reactivated southern border of an E-W mafic dyke (along the Svartebekk river, site18).

2.4.10 Brittle tectonics along the Reineelva river (site 4)

Along the nearly N-S running Reineelva river in the Permian syenites (site 4), in addition to many sets of joints, jointed and faulted mafic dykes are observed (Figure 33). The first trends N-S and is the river bed (Figure 34) and the second is NW-SE (Figure 35). As for the mafic dykes along the Sagdalen valley (see paragraph 2.4.8), one can observed the large increase of joint density into the dykes along the Reineelva river (above 10 fractures/m; Figure 34). In addition to the numerous open joints into the dykes, the presence of uncemented breccia along the faulted dyke borders may significantly contribute to an increase in permeability.

Both the host syenite and the basalt of a N-S dyke were sampled to study the micro-fracturation in thin-sections (samples R1 and R2 respectively in Appendix B). Whereas the dykes are more fractured at the outcrop scale, no micro-fracture was observed in the thin section. Some few partly filled veins and diffuse patches of secondary mineral (prehnite?) were seen in the thin section of the syenite. No open micro-fractures can contribute to a significant increase of the permeability of the dykes.

Site 4 is in the area of NW-SE and N-S first order discontinuities (see Figure 6). The observations made at this site also confirm that the large lineaments may be brecciated normal faults and mafic dykes. Specifically, the N-S lineament along the Reineelva river is a highly fractured dyke with a brecciated border. As mentioned in paragraph 2.3.1, it crosses the segment D of the Numedalen valley (cf. Figure 1B) and because it is a weak zone compared to the surrounding, it has been strongly eroded (Figure 8).

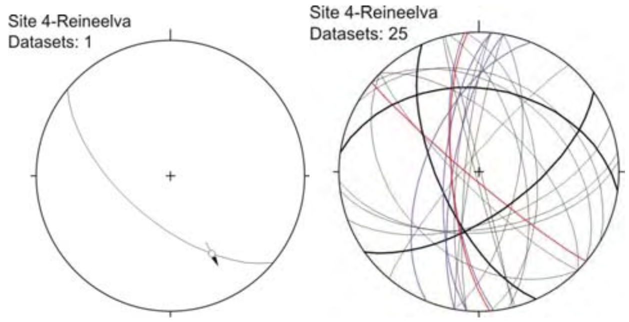
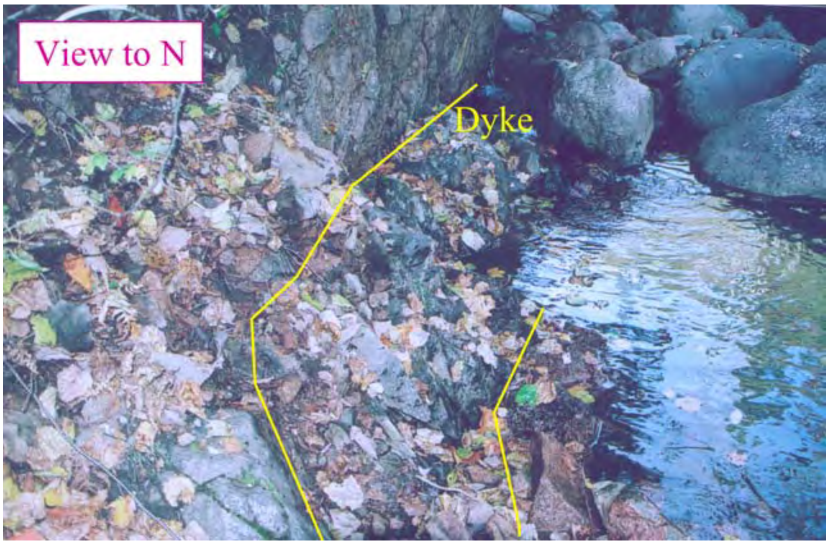


Figure 33. Stereonets of brittle structures in the Permian syenites along the Reineelva river (keys to stereonet provided in Figure 10 and Figure 11).



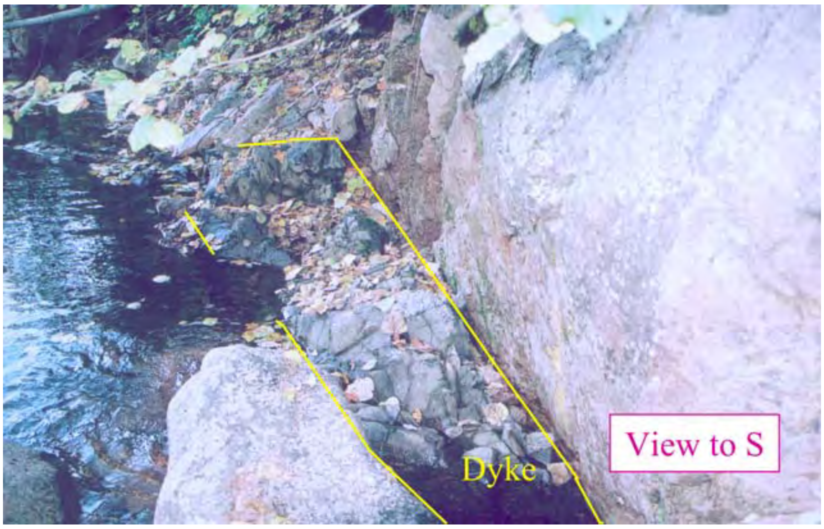


Figure 34. Photos of N-S mafic dyke along the Reineelva river (strikes and dip angles of the dyke borders: 185/70; 190/75). The dyke displays a larger joint density than the host syenite (like the dykes observed along the Sagdalen valley).

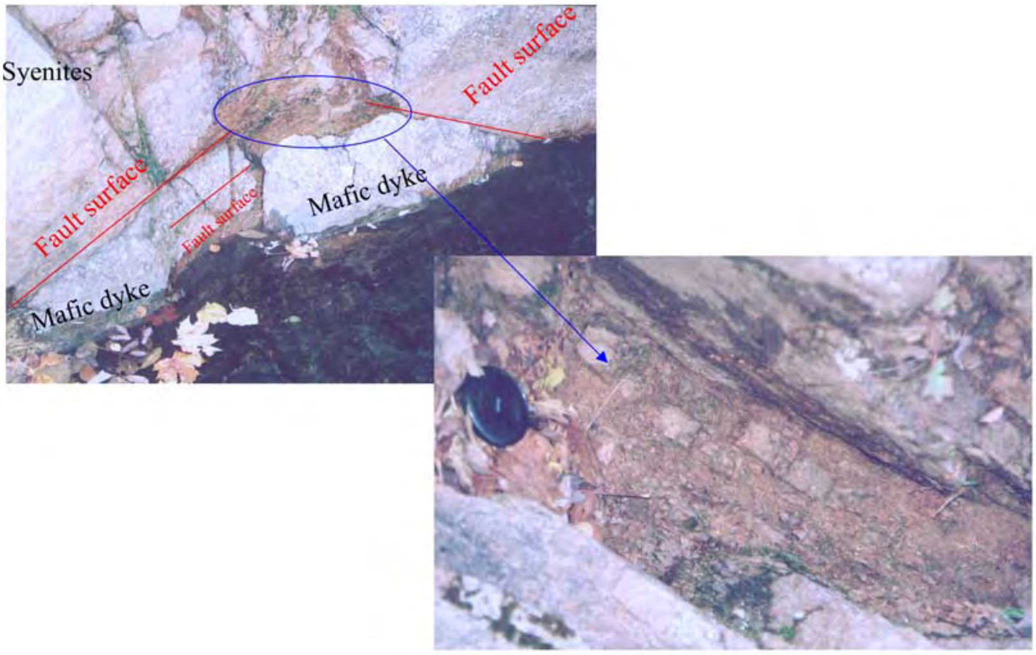


Figure 35. Photos of a NW-SE striated fault with patches of uncemented breccias (in blue circle) along the Reineelva river (strike and dip angle: 130/62 and pitch 40E). This fault also separates a mafic dyke and the host syenite.

2.4.11 <u>Brittle tectonics in Hvittingfoss area (site 3)</u>

Site 3 is the southernmost field location in the investigated area and is located where the Numedalen valley trends N-S southwards from Hvittingfoss (segment E on Figure 1B). In the Permian syenites, both NW-SE to NNE-SSW mafic dykes and felsic (pegmatitic) veins were measured (Figure 36), with an ENE-WSW probably normal fault. The trends of brittle structures at this site are similar to the large linear features of the region (see Figure 6). The basaltic dykes display a high joint frequency (Figure 37). To better characterise the fractures in the dykes, a 50 cm wide vertical N170 striking basaltic dyke was sampled (Figure 37, sample 4K, Appendix B) for thin section analysis. A dense network of mineralised tension gashes is present in the thin section with high angle crosscutting relationships between the fractures. The mineral infill is complete and probably of prehnite. As the micro-fractures of this particular dyke are sealed they do not contribute to the permeability of the rock.

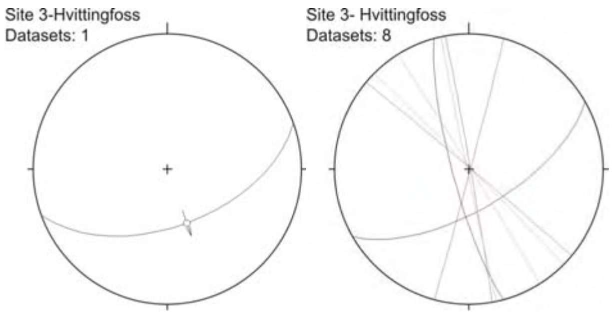


Figure 36. Stereonets of brittle structures in the Permian syenites south of Hvittingfoss (keys to stereonet provided in Figure 10 and Figure 11).

Figure 37. 50 cm wide, vertical and N170 striking basaltic dyke intruded in the syenite. The dyke displays a dense fracture network (more than 10 fractures/m), the basalt was sampled and a thin section analysed (Hans De Beer for scale, photo by courtesy of Atle Dagestad).

2.4.12 Summarizing the hydraulic properties of major brittle structures using qualitative field observations of brittle tectonics in sub-areas along the Numedalen valley

The field observations in 11 sub-areas along the Numedalen valley have permitted identification and characterization of the large sets of lineaments. They all corresponds to large brittle structures and Table 1 summarizes their estimated permeability. The large brittle structures trend for the most NE-SW, NW-SE and N-S. The most probable conduits for ground water flow are the NW-SE and the N-S large fracture systems. The NW-SE set is recognised in 4 sub areas and mainly in the southern part of the studied area as prominent faults and dykes. A dense fracture network (above 9 fractures/m) characterised the faults and the dykes that likely makes the structures permeable to water. The N-S set is large dykes, typical of the southern part of the studied area. Because of their high density of fractures (above 10 fractures/m), they could be large conduits for groundwater. The NE-SW set of large structures has been only well identified in the Svartebekk area whereas this trend has been observed in five sub-areas at the scale of the outcrops. It corresponds to large faults filled with uncemented breccias and to highly jointed dykes; subsequently, both the faults and the dykes should be considered permeable. It is only in two sub-areas that the minor set of E-W large structures has been observed. In spite of that, at both, they correspond to steep crushed zones, with the uncemented fine-grained crushed material providing a high permeability.

	NE-SW large structures	NW-SE large structures	N-S large structures	Few E-W large structures
Kongsberg area (Gamlegrendåsen) (sites 30, 35 and 36) Paragraph 2.4.1	Observed No conclusion	Observed No conclusion		
Skollenborg - Hassel (sites 5, 6 and 34) Paragraph 2.4.2	Observed Faults No conclusion			
Jartkjær lake (sites 7, 8, 9, 20 and 21) Paragraph 2.4.3		Observed Highly fractured fault zone Probably permeable		
Damvanna lake (sites 24 and 25) Paragraph 2.4.4	Observed Fault zone and dyke Probably no higher permeability than host rocks	Observed No conclusion		
Sauar- Lindum area (sites 22, 23, 26 and 27) Paragraph 2.4.5	Observed Faults No conclusion	Observed No conclusion		
Støleelva river (sites 14, 15 and 16) Paragraph 2.4.6		Observed Faults No conclusion		Observed Crushed fault zone Highly permeable
Rud-Gran-Ånnestad area (sites 1, 2, 28, 29, 31, 32 and 33) Paragraph 2.4.7		Observed Dyke No conclusion	Observed-Fault and dyke Probably highly permeable	
Sagdalen valley (sites 10, 11, 12, 13 and 19) Paragraph 2.4.8	Highly fractured fault zone (NNE-SSW) Highly permeable	Observed Dyke Highly permeable	Observed-Fault-no conclusion	
Svartebekk river (sites 17 and 18) Paragraph 2.4.9	Observed-Fault and dyke Probably highly permeable			Observed Crushed fault zone Highly permeable
Reineelva river (site 4) Paragraph 2.4.10		Observed Highly fractured dykes and uncemented breccia at the faulted borders Highly permeable	Observed Highly fractured dykes and uncemented breccia at the faulted borders Highly permeable	
Hvittingfoss area (site 3) Paragraph 2.4.11		Observed Highly fractured dykes Probably highly permeable	Observed Highly fractured dykes Probably highly permeable	

Table 1. Qualitative assessment for the hydraulic properties of major brittle structures using field observations of brittle tectonics in sub-areas along the Numedalen valley. Trends of large structures are extracted from remote sensing data (Cf. paragraph 2.3.1) and confirmed by the field observations. 'Observed' means that the large structural trends are observed at the scale of the outcrop and can be somehow characterised (see detailed description in corresponding paragraphs). 'No conclusion' means that despite the fact that the trends of major structures are the trends observed at the scale of the outcrop, one cannot provide any settlement on their actual nature and hence, their role in the hydrogeological system along the valley.

3 CONCLUSION: BRITTLE TECTONICS AND ITS RELEVANCE FOR THE HYDROGEOLOGY OF THE NUMEDALEN VALLEY

At the regional scale, the granitic massif is characterised by large NW-SE lineaments and by a secondary NE-SW trend. The monzonite and rhomb porphyries massifs are characterised by both N-S and NW-SE large lineaments. The changing directions of the Numedalen valley between Hvittingfoss and Kongsberg are controlled by bedrock geology and the large lineaments. The NW-SE and N-S segments of the valley trends parallel to these large discontinuities, recognised in this field study as major normal faults and mafic dykes. The same may be concluded for the large set of NE-SW lineaments. They correspond also to normal faults and dykes according to the brittle structures identified at the local scale. Also the different trends of tensile brittle structures indicate and confirm that the area was under different trends of tensional stresses related to the development of the Oslo Rift (e.g. Heeremans et al., 1996).

Along the valley, some bedrock structures beneath the Quaternary sedimentary deposits are identified from geophysical surveys and can be related to large lineaments as faults, dykes and faulted dykes. Large NE-SW fault zones are invoked to explain the formation of a structural high in the middle of the Numedalen valley where it runs onto the granitic massif. This structure in the bedrock is also responsible for a shift in the axis of the depocentres of the Quaternary sedimentary deposits. The Sagdalen and Reineelva tributary rivers are both lying on large lineaments. Along the Reineelva river, N-S trending dyke and faulted dyke borders with uncemented fault rocks are observed. The prolongation of these two lineaments, and of the respective riverbeds, is also well displayed in the resistivity survey along the Numedalen valley with a sharp and deep incision in the bedrock surface. Such incision by the rivers might have been possible because of the weakness of the fault zones.

The fault zones generally display a higher permeability than the host rock by an increase of fracture density and the occurrence of uncemented brecciated fault cores. The basaltic dykes are in general more jointed that the host rocks, and display a high connectivity of their fracture network. The fracture density of the dykes is comparable to the values of fracture density given in literature for the permeable damage zone of a fault. It is thus assumed that the permeability through the dykes is significantly higher than in the host rock (even if some closure of fractures may occur at depth).
In many studied sites that lie in the host rocks (away from large fracture zones), the frequency of fractures can be significant and above 5 fractures/m. These fractures are typically several sets of cut-crossing joints. Their connectivity is certain at the surface. They are commonly not sealed by minerals and hence, one can consider they are open (with a very few amount of aperture). These observations allow to argue for a slow infiltration and percolation of water through the joints in the host rocks.
At the micro-scale, open and/or sealed or no fractures are observed in the rock samples without any correlation with the fractures at the scale of the outcrops. As such, some of the highly fractured dykes do not display fractures at the micro-scale or display sealed micro-fractures whereas the fractures are open at the scale of the outcrop. However, the analyses of the micro-fractures concerns the long-term water circulation through the rock mass, i.e. the secondary fracture porosity and the percolation, and not the rapid water flow that can occur along large fracture zones, with a high hydraulic conductivity.

The surficial drainage shows a large anisotropy in direction as it is guided by the large discontinuities. The same anisotropy may be postulated for the major part of the groundwater flow. The surficial water network (rivers and lakes) lying on the high plateaus is probably a good reservoir for the groundwater which may be conducted by the permeable large fracture zones and dykes down to the Numedalen valley. For an example, the large N-S faulted dyke along the Reineelva river may be a good ground water conduit from the top of the plateaus (i.e. the lakes) down to the Numedalen valley. Some of the NW-SE large fracture and fault zones located in the granitic massif can also be conduits to the ground water flow. Hence, a predictive model of the anisotropy of the ground water flow is proposed based on the high quality field observations made in the western part of the area (Figure 38). This model implies that the large conduits are somehow connected. It does not take into account the possible slow infiltration and percolation of water through the joint systems (commonly observed on the field and away from the large structures). This model should be further tested.

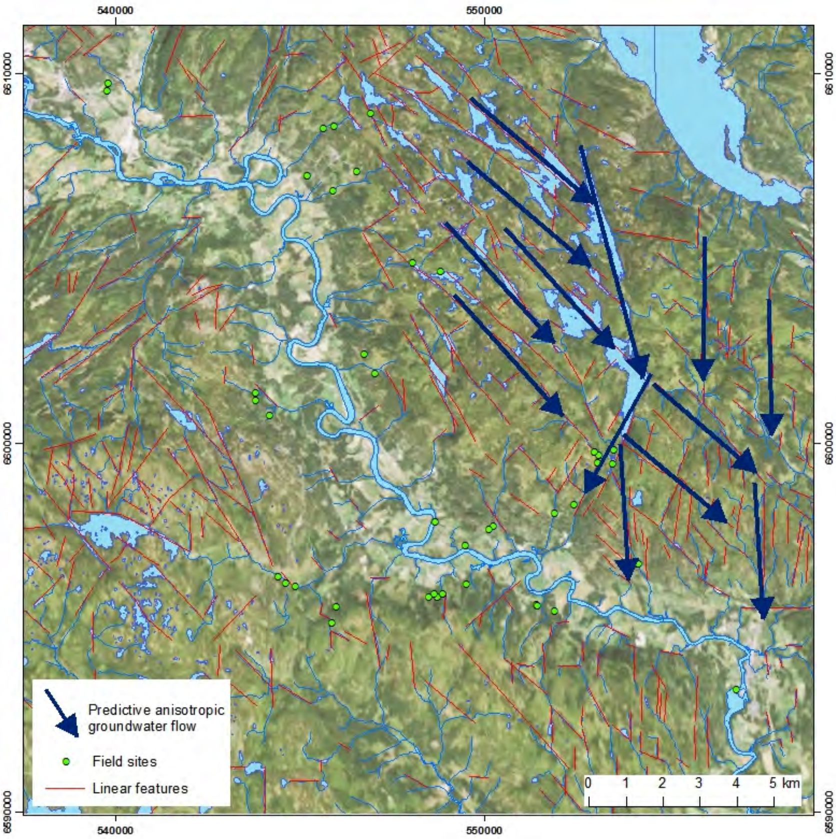


Figure 38. Predictive model of the groundwater flow in the western part of the area where high quality field observations allow to qualitatively estimate the high permeability of large dykes and faults.

4 REFERENCES

Braathen, A., Osmundsen, P.T., Gabrielsen, R., 2004. Dynamic development of fault rocks in a crustal-scale detachment; an example from western Norway. Tectonics, 23, TC4010, doi:10.1029/2003TC001558.

Caine, J.S., Evans, J.P., Forster, C.B., 1996. Fault zone architecture and permeability structure. Geology, 24, 11, 1025-1028.

Evans, J.P., Forster, C.B., Goddard, J.V., 1997. Permeability of fault-related rocks, and implications for hydraulic structure of fault zones. Journal of Structural Geology, 19, 1393-1404.

Gudmundsson, A., Berg, S.S., Lyslo, K.B., Skurtveit, E., 2001. Fracture networks and fluid transport in active fault zones. Journal of Structural Geology, 23, 2-3, 343-353. 0191-8141.

Heeremans, M., Larsen, B.T., Stel, H., 1996. Paleostress reconstruction from kinematic indicators in the Oslo Graben, southern Norway: new constraints on the mode of rifting, Tectonophysics, 266, 55-79.

Holm, M.P. and O. Larsen, 1997. Berggrunnskart SILJAN 1713 I, M 1:50 000. NGU.

Jones, M.A., Pringle, A.B., Fulton, I.M., O'Neill, S., 1999. Discrete fracture network modelling applied to groundwater resource exploitation in southwest Ireland. In: McCaffrey, K.J.W., Lonergan, L. & Wilkinson, J.J. (eds), Fractures, fluid flow and mineralization. Geological Society of London, Special Publication, 155, 83-103.

Munier, R., Stanfors, R., Milnes, A.G., Hermanson, J., Triumf, C.A., 2003. Geological Site Descriptive Model. A strategy for the development during site investigations. SKB R-0 -07, Svensk Kärnbränslehantering AB.

Neretnieks, I., 1985. Transport in fractured rocks, in *Proceedings of Hydrogeology of Rock of Low Permeability, Mem. Intern. Assoc. Hydrogeol*., *17*(2), 301–318, 1985

Nilsen, K.S. and A. Siedlecka, 2003. Berggrunnskart KONGSBERG 1714 II, M 1:50 000. NGU.

Sibson, R.H., 1977, Fault rocks and fault mechanisms Journal geol. Soc. Lond. vol. I33 , pp. 191-213,

SkyTEM 2006. SkyTEM Survey – Numedal, Data Report. Report 2006.01.02, Aarhus, 24 p.

Tønnesen, J.F., 1978. Geofysiske undersøkelser av kvartære sedimenter i Numedal. Hovedoppgave i geofysikk/kvartærgeologi, Institutt for geologi, Universitetet i Oslo.

Acknowledgements. Many thanks to Guri Venvik, Atle Dagestad, Hans De Beer, Giulio Viola for their comments /corrections and for fruitful discussions on the topic.

Appendix A

Measurements

Site number	Locality	UTM32V X	UTM32V Y	Rocks	Structure	Strike	Dip angle	Pitch
Site 1	South of Øvre	548704	6595854	Permian rhomb porphyry and syenite	Joint	236	27	
Site 1	South of Øvre	548704	6595854	Permian rhomb porphyry and syenite	Joint	350	80	
Site 1	South of Øvre	548704	6595854	Permian rhomb porphyry and syenite	Joint	265	85	
Site 1	South of Øvre	548704	6595854	Permian rhomb porphyry and syenite	Joint	260	89	
Site 1	South of Øvre	548704	6595854	Permian rhomb porphyry and syenite	Joint	270	80	
Site 1	South of Øvre	548621	6595918	Permian rhomb porphyry and syenite	Joint	175	70	
Site 1	South of Øvre	548621	6595918	Permian rhomb porphyry and syenite	Joint	270	80	
Site 1	South of Øvre	548621	6595918	Permian rhomb porphyry and syenite	Joint	15	89	
Site 1	South of Øvre	548621	6595918	Permian rhomb porphyry and syenite	Joint	20	88	
Site 1	South of Øvre	548863	6595941	Permian rhomb porphyry and syenite	Joint	170	80	
Site 1	South of Øvre	548863	6595941	Permian rhomb porphyry and syenite	Joint	94	12	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Probably sinistral stria	355	70	58N
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Dyke of basalt (30 cm wide)	190	87	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Dyke of basalt (50 cm wide with blocks of rhomb porphyry)	185	85	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Dyke of basalt (1,5 m wide)	190	85	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Dyke of basalt (10 cm wide)	190	70	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Dyke of basalt (sample 3K) 10 cm wide	5	85	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	180	89	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	130	85	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	300	56	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	130	58	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	10	85	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	125	60	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	112	56	

Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	36	85	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	218	45	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	323	12	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	325	20	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	315	70	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	190	80	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	310	68	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	190	62	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	315	79	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	306	77	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	310	78	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	348	68	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	339	76	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	293	58	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	218	51	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	343	12	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	315	85	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	16	88	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	20	88	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	18	89	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	304	60	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	225	70	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	309	62	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	23	83	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	304	57	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	33	89	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	308	58	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	199	88	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	292	64	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	165	70	

Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	123	79	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	168	76	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	150	80	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	150	83	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	60	83	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	260	50	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	285	68	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	318	65	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	155	88	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	200	50	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	267	49	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Large joints	134	80	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Large joints	125	78	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	274	58	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	282	88	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	277	43	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	130	85	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	16	85	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	98	89	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	0	89	
Site 2	Solum	551392	6595645	Permian rhomb porphyry	Joint	313	50	
Site 3	Hvittingfoss	556815	6593323	Permian granite	Probably normal stria	70	55	90
Site 3	Hvittingfoss	556815	6593323	Permian granite	Joint	165	80	
Site 3	Hvittingfoss	556815	6593323	Permian granite	Joint	60	65	
Site 3	Hvittingfoss	556815	6593323	Permian granite	Pegmatitic dyke	328	89	
Site 3	Hvittingfoss	556815	6593323	Permian granite	Pegmatitic dyke	315	89	
Site 3	Hvittingfoss	556815	6593323	Permian granite	Sample 4K- basaltic dyke	350	89	
Site 3	Hvittingfoss	556815	6593323	Permian granite	Pegmatitic dyke	168	89	
Site 3	Hvittingfoss	556815	6593323	Permian granite	Mafic dyke	15	89	
Site 3	Hvittingfoss	556815	6593323	Permian granite	Mafic dyke	310	89	

Site 4	Reineelva	554151	6596741	Permian syenite	Sinistral stria	130	62	40E
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	315	60	
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	135	40	
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	348	64	
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	86	54	
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	355	56	
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	346	89	
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	135	80	
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	190	85	
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	10	67	
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	185	82	
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	82	56	
Site 4	Reineelva	554151	6596741	Permian syenite	Basaltic dyke	185	70	
Site 4	Reineelva	554151	6596741	Permian syenite	Basaltic dyke	174	74	
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	310	40	
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	220	82	
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	300	32	
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	185	77	
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	70	60	
Site 4	Reineelva	554151	6596741	Permian syenite	Joint	165	88	
Site 4	Reineelva	554151	6596741	Permian syenite	1 m wide basaltic dyke	190	75	
Site 4	Reineelva	554151	6596741	Permian syenite	Damage zone	130	85	
Site 4	Reineelva	554151	6596741	Permian syenite	Basaltic dyke	202	58	
Site 4	Reineelva	554151	6596741	Permian syenite	Large joint	156	66	
Site 4	Reineelva	554151	6596741	Permian syenite	Large joint	55	64	
Site 4	Reineelva	554151	6596741	Permian syenite	Large joint	278	40	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Bedding plane	29	3	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Bedding plane	8	10	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Bedding plane	23	11	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Bedding plane	24	10	

Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Bedding plane	10	10	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Bedding plane	10	12	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Tension gash	90	84	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Tension gash	284	88	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Tension gash	202	78	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Tension gash	202	72	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Tension gash	245	72	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Tension gash	178	82	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Tension gash	268	83	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Tension gash	172	88	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Tension gash	175	78	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Tension gash	252	69	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Tension gash	208	80	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	88	80	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	160	83	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	179	85	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	198	83	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	90	80	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	332	89	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	192	85	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	240	80	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	35	88	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	165	88	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	248	78	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	190	89	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	239	79	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	187	80	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	53	89	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	152	87	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	245	80	

Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	180	85	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	246	81	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	103	89	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	174	82	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	245	66	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	244	82	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	340	84	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	245	78	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	169	82	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	240	64	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	0	89	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	90	80	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	194	82	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	245	78	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	335	89	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	192	88	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	245	80	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	193	85	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	233	80	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	190	86	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	240	79	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	182	78	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	205	82	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	250	76	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	183	80	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	198	86	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	162	88	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	100	76	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	240	74	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	98	89	

Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	280	84	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	170	80	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	280	83	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	250	75	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	178	82	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	242	70	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	15	84	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	248	69	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	192	78	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	243	78	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	164	85	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	240	75	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	282	89	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	160	86	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	248	72	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	170	78	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	74	82	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	198	83	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	215	82	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	198	84	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	182	85	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	250	70	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	160	89	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	182	84	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	280	82	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	198	80	
Site 5	Hassel-Vegu	542608	6613357	Lower Paleozoic sediments	Joint	90	78	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	230	80	85E
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	230	80	3W
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	170	80	80S

Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	202	86	40S
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	90	74	82W
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	200	76	40S
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	105	38	72W
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	105	39	52E
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	292	82	2W
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	198	75	55S
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	100	44	61W
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	305	65	10W
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	90	45	76E
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	250	86	42W
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Probably sinistral stria	225	80	18W
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	232	85	40E
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	95	39	62E
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Probably dextral stria	86	44	58E
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Dextral fault	64	89	44E
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Probably dextral stria	217	63	47S
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	225	66	33W
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Dextral fault	93	46	61E
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	54	78	56E
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	60	89	59W
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	54	89	10W
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	234	80	1W
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Normal fault	34	70	60N
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	255	62	55W
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	235	85	32W
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	68	82	74W
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	240	88	60E
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Probably reverse stria	90	42	48W
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Dextral fault	210	87	35S

Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Striated fault	218	83	43S
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Probably dextral stria	314	89	50E
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	60	89	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	255	72	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	198	72	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	275	85	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	200	80	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	270	75	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	212	83	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	150	67	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	142	65	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Tension gash	218	62	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	208	75	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Tension gash	184	60	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Tension gash	216	65	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	46	89	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	56	86	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	305	89	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Tension gash	207	69	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	220	70	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	230	85	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	52	89	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	55	89	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	134	84	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	78	89	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	55	82	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	100	38	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	98	42	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	190	72	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	90	33	

Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	200	74	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	274	88	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	78	89	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	258	88	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	133	70	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	100	30	
Site 6	Skollenborg	539824	6609764	Proterozoic gabbros, amphibolites	Joint	308	72	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	190	86	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	348	85	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	358	87	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	118	80	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	10	88	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	187	80	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	175	5	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	135	19	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	130	5	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	125	70	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	115	70	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	100	75	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	122	10	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	70	89	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	155	12	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	85	85	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	97	72	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	350	89	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	140	10	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	263	85	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	357	89	
Site 7	East of Haugnes	545195	6607245	Permian granite	Joint	358	88	
Site 8	West of Damtjernet	546534	6607358	Permian granite				

Site 9	Ognevanna	545923	6608601	Permian granite	Joint	90	89	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	265	65	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	260	72	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	270	75	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	272	76	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	262	73	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	264	70	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	171	84	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	183	6	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	172	26	
Site 9	Ognevanna	545923	6608601	Permian granite	1 m spaced set of joint	185	40	
Site 9	Ognevanna	545923	6608601	Permian granite	1 m spaced set of joint	175	35	
Site 9	Ognevanna	545923	6608601	Permian granite	1 m spaced set of joint	172	30	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	270	66	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	292	80	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	45	88	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	284	75	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	225	73	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	138	89	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	48	89	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	263	79	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	167	62	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	265	70	
Site 9	Ognevanna	545923	6608601	Permian granite	Joint	260	75	
Site 10	Komneslia	551892	6598114	Permian syenite				
Site 11	Sagdalen	553056	6599477	Permian syenite	1m wide basaltic dyke -sample 5k	120	80	
Site 11	Sagdalen	553056	6599477	Permian syenite	1m wide basaltic dyke -sample 5k	130	80	
Site 11	Sagdalen	553056	6599477	Permian syenite	2m wide basaltic dyke -sample 6k	145	80	
Site 11	Sagdalen	553056	6599477	Permian syenite	2m wide basaltic dyke -sample 6k	160	80	
Site 11	Sagdalen	553056	6599477	Permian syenite	Normal fault	200	30	

Site 11	Sagdalen	553056	6599477	Permian syenite	Maybe normal fault	190	62	
Site 11	Sagdalen	553056	6599477	Permian syenite	Epidote coating	237	62	
Site 11	Sagdalen	553056	6599477	Permian syenite	Joint	185	80	
Site 11	Sagdalen	553056	6599477	Permian syenite	10 cm spaced set of joints	310	89	
Site 11	Sagdalen	553056	6599477	Permian syenite	Joint	215	40	
Site 11	Sagdalen	553056	6599477	Permian syenite	Border of 1 m wide basaltic dyke	335	89	
Site 11	Sagdalen	553056	6599477	Permian syenite	Border of 1 m wide basaltic dyke	338	89	
Site 11	Sagdalen	553056	6599477	Permian syenite	1 m wide basaltic dyke	155	89	
Site 11	Sagdalen	553056	6599477	Permian syenite	Border of 2 m wide basaltic dyke	310	89	
Site 11	Sagdalen	553056	6599477	Permian syenite	Border of 2 m wide basaltic dyke	125	89	
Site 11	Sagdalen	553056	6599477	Permian syenite	Border of 3 m wide basaltic dyke	334	89	
Site 11	Sagdalen	553056	6599477	Permian syenite	Border of 3 m wide basaltic dyke	335	89	
Site 11	Sagdalen	553056	6599477	Permian syenite	Border of 1 m wide basaltic dyke	140	89	
Site 11	Sagdalen	553056	6599477	Permian syenite	Border of 1 m wide basaltic dyke	170	89	
Site 11	Sagdalen	553056	6599477	Permian syenite	Border of 5 m wide basaltic dyke	330	89	
Site 11	Sagdalen	553056	6599477	Permian syenite	Border of 5 m wide basaltic dyke	340	89	
Site 11	Sagdalen	553056	6599477	Permian syenite	Supposed normal stria	185	68	50N
Site 11	Sagdalen	553056	6599477	Permian syenite	Certain normal stria	178	63	55N
Site 11	Sagdalen	553056	6599477	Permian syenite	Striated fault	185	78	40N
Site 11	Sagdalen	553056	6599477	Permian syenite	Certain normal stria	180	64	40N
Site 11	Sagdalen	553056	6599477	Permian syenite	Certain normal stria	172	62	52N
Site 12	Sagdalen	552960	6599779	Permian syenite	1m wide basaltic dyke -sample 7k	170	75	
Site 12	Sagdalen	552960	6599779	Permian syenite	Basaltic dyke	160	89	
Site 12	Sagdalen	552960	6599779	Permian syenite	Joint	320	89	
Site 12	Sagdalen	552960	6599779	Permian syenite	Joint	330	89	
Site 12	Sagdalen	552960	6599779	Permian syenite	Joint	95	62	
Site 12	Sagdalen	552960	6599779	Permian syenite	Joint	240	89	
Site 12	Sagdalen	552960	6599779	Permian syenite	Joint	70	59	
Site 12	Sagdalen	552960	6599779	Permian syenite	Joint	155	70	
Site 12	Sagdalen	552960	6599779	Permian syenite	Epidote rich plane	162	82	

Site 12	Sagdalen	552960	6599779	Permian syenite	Joint	110	66	
Site 12	Sagdalen	552960	6599779	Permian syenite	Epidote coated plane	162	85	
Site 12	Sagdalen	552960	6599779	Permian syenite	Joint	336	78	
Site 12	Sagdalen	552960	6599779	Permian syenite	Joint	332	89	
Site 12	Sagdalen	552960	6599779	Permian syenite	Fine vein	72	85	
Site 12	Sagdalen	552960	6599779	Permian syenite	Joint	296	80	
Site 12	Sagdalen	552960	6599779	Permian syenite	Certain normal stria	100	82	87E
Site 12	Sagdalen	552960	6599779	Permian syenite	Certain normal stria on epidote coated plane	190	30	90
Site 12	Sagdalen	552960	6599779	Permian syenite	Certain dextral stria	80	89	76E
Site 13	Sagdalen	552420	6598347	Permian syenite	5 m wide basaltic dykes -sample 8k	160	89	
Site 13	Sagdalen	552420	6598347	Permian syenite	5 m wide basaltic dykes -sample 8k	150	89	
Site 14	Støleelva	544415	6596405	Permian granite	Striated fault	316	60	90
Site 14	Støleelva	544415	6596405	Permian granite	Striated fault	352	70	80S
Site 14	Støleelva	544415	6596405	Permian granite	Tension gash	80	85	
Site 14	Støleelva	544415	6596405	Permian granite	Normal fault	310	75	
Site 14	Støleelva	544415	6596405	Permian granite	Joint	345	68	
Site 14	Støleelva	544415	6596405	Permian granite	Joint	276	84	
Site 14	Støleelva	544415	6596405	Permian granite	Joint	334	89	
Site 14	Støleelva	544415	6596405	Permian granite	Joint	87	89	
Site 14	Støleelva	544415	6596405	Permian granite	Joint	338	89	
Site 14	Støleelva	544415	6596405	Permian granite	Joint	277	83	
Site 14	Støleelva	544415	6596405	Permian granite	Joint	158	69	
Site 14	Støleelva	544415	6596405	Permian granite	Joint	97	85	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	258	80	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	330	64	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	98	89	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	358	80	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	82	84	

Site 14	Støleelva	544608	6596213	Permian granite	Joint	310	85	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	334	69	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	84	88	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	315	78	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	266	84	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	310	72	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	325	78	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	90	89	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	333	77	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	89	89	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	337	83	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	296	76	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	110	89	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	328	82	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	90	87	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	328	89	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	332	76	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	20	44	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	14	37	
Site 14	Støleelva	544608	6596213	Permian granite	Fault	80	80	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	350	50	
Site 14	Støleelva	544608	6596213	Permian granite	Joint	99	85	
Site 15	Rudåsen	545858	6595133	Permian syenite	Joint	2	89	
Site 15	Rudåsen	545858	6595133	Permian syenite	Joint	150	78	
Site 15	Rudåsen	545858	6595133	Permian syenite	Joint	204	77	
Site 15	Rudåsen	545858	6595133	Permian syenite	Joint	197	89	
Site 15	Rudåsen	545858	6595133	Permian syenite	Joint	130	78	
Site 15	Rudåsen	545858	6595133	Permian syenite	Joint	191	89	
Site 15	Rudåsen	545858	6595133	Permian syenite	Joint	147	80	
Site 15	Rudåsen	545858	6595133	Permian syenite	Joint	218	74	

Site 15	Rudåsen	545858	6595133	Permian syenite	Joint	134	78	
Site 15	Rudåsen	545858	6595133	Permian syenite	Joint	9	89	
Site 15	Rudåsen	545858	6595133	Permian syenite	Joint	180	20	
Site 15	Rudåsen	545858	6595133	Permian syenite	Joint	0	84	
Site 16	Rudåsen	545987	6595575	Permian syenite	Joint	28	89	
Site 16	Rudåsen	545987	6595575	Permian syenite	Joint	297	70	
Site 16	Rudåsen	545987	6595575	Permian syenite	Joint	10	89	
Site 16	Rudåsen	545987	6595575	Permian syenite	Joint	357	85	
Site 16	Rudåsen	545987	6595575	Permian syenite	Joint	296	85	
Site 16	Rudåsen	545987	6595575	Permian syenite	Joint	194	82	
Site 16	Rudåsen	545987	6595575	Permian syenite	Joint	315	84	
Site 16	Rudåsen	545987	6595575	Permian syenite	Joint	180	20	
Site 16	Rudåsen	545987	6595575	Permian syenite	Joint	200	20	
Site 16	Rudåsen	545987	6595575	Permian syenite	Joint	204	82	
Site 16	Rudåsen	545987	6595575	Permian syenite	Joint	118	60	
Site 16	Rudåsen	545987	6595575	Permian syenite	Joint	214	82	
Site 16	Rudåsen	545987	6595575	Permian syenite	Joint	128	70	
Site 16	Rudåsen	545987	6595575	Permian syenite	Joint	198	86	
Site 16	Rudåsen	545987	6595575	Permian syenite	Joint	285	76	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	330	89	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	20	79	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	358	70	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	338	85	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	15	84	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	167	79	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	194	87	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	292	81	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	346	85	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	210	62	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	169	74	

Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	187	80	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	310	89	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	285	85	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	290	83	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	180	75	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	250	80	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	50	85	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	305	70	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	60	59	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	285	78	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	80	78	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	200	72	
Site 17	Svartebekk	553503	6599834	Permian syenite	Joint	45	20	
Site 17	Svartebekk	553503	6599834	Permian syenite	Striated fault	210	83	63N
Site 17	Svartebekk	553503	6599834	Permian syenite	Striated fault	213	89	62N
Site 17	Svartebekk	553503	6599834	Permian syenite	Striated fault	20	82	48N
Site 17	Svartebekk	553503	6599834	Permian syenite	Striated fault	20	59	50N
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	270	71	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	138	70	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	267	77	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	70	62	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	272	83	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	134	80	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	55	55	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	269	83	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	129	79	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	130	80	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	130	83	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	152	84	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	150	65	

Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	158	82	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	86	89	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	150	78	
Site 18	Svartebekk	553452	6599440	Permian syenite	Southern border of 4 m wide rhomb porphyry dyke	252	87	
Site 18	Svartebekk	553452	6599440	Permian syenite	Northern border of 4 m wide rhomb porphyry dyke	50	89	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	312	89	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	73	89	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	162	66	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	231	81	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	252	80	
Site 18	Svartebekk	553452	6599440	Permian syenite	Large fault	260	60	
Site 18	Svartebekk	553452	6599440	Permian syenite	Dyke of fine grained syenite	250	50	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	266	85	
Site 18	Svartebekk	553452	6599440	Permian syenite	Joint	151	72	
Site 18	Svartebekk	553452	6599440	Permian syenite	Normal stria	149	81	89S
Site 18	Svartebekk	553452	6599440	Permian syenite	Normal stria	254	78	76W
Site 18	Svartebekk	553452	6599440	Permian syenite	Normal stria	238	80	75W
Site 18	Svartebekk	553452	6599440	Permian syenite	Normal stria	266	75	90
Site 18	Svartebekk	553452	6599440	Permian syenite	Normal stria	238	74	80E
Site 18	Svartebekk	553452	6599440	Permian syenite	Normal striae along dyke-brecciated zone10 cm	252	87	86E
Site 18	Svartebekk	553452	6599440	Permian syenite	Normal striae	343	86	56S
Site 18	Svartebekk	553452	6599440	Permian syenite	Normal stria	173	62	90
Site 18	Svartebekk	553452	6599440	Permian syenite	Normal stria	244	65	57W
Site 18	Svartebekk	553452	6599440	Permian syenite	Normal stria	178	66	80S
Site 19	Sagdalen	553069	6599672	Permian syenite	Joint	314	85	
Site 19	Sagdalen	553069	6599672	Permian syenite	Joint	145	72	
Site 19	Sagdalen	553069	6599672	Permian syenite	Joint	272	82	
Site 19	Sagdalen	553069	6599672	Permian syenite	Joint	162	78	

Site 19	Sagdalen	553069	6599672	Permian syenite	Joint	120	89	
Site 19	Sagdalen	553069	6599672	Permian syenite	Joint	187	58	
Site 19	Sagdalen	553069	6599672	Permian syenite	Joint	280	80	
Site 19	Sagdalen	553069	6599672	Permian syenite	Large joint with calcite coating	328	89	
Site 19	Sagdalen	553069	6599672	Permian syenite	Large joint with calcite coating	322	85	
Site 19	Sagdalen	553069	6599672	Permian syenite	Joint	280	88	
Site 19	Sagdalen	553069	6599672	Permian syenite	Joint with hematite coating	280	78	
Site 19	Sagdalen	553069	6599672	Permian syenite	SW-border of 2 m wide basaltic dyke	142	72	
Site 19	Sagdalen	553069	6599672	Permian syenite	NE-border of 2 m wide basaltic dyke	330	89	
Site 19	Sagdalen	553069	6599672	Permian syenite	Probably sinistral stria	148	80	3N
Site 19	Sagdalen	553069	6599672	Permian syenite	Probably dextral stria	280	70	1E
Site 19	Sagdalen	553069	6599672	Permian syenite	Striated fault	303	89	18E
Site 19	Sagdalen	553069	6599672	Permian syenite	Probably sinistral stria	276	75	6W
Site 19	Sagdalen	553069	6599672	Permian syenite	Probably sinistral stria	312	84	20E
Site 19	Sagdalen	553069	6599672	Permian syenite	Sinistral stria	105	89	5E
Site 19	Sagdalen	553069	6599672	Permian syenite	Sinistral stria	324	89	1S
Site 19	Sagdalen	553069	6599672	Permian syenite	Sinistral stria	158	73	3S
Site 19	Sagdalen	553069	6599672	Permian syenite	Supposed sinistral stria	150	82	13N
Site 19	Sagdalen	553069	6599672	Permian syenite	Sinistral stria	14	58	67S
Site 19	Sagdalen	553069	6599672	Permian syenite	Sinistral stria	30	62	67S
Site 19	Sagdalen	553069	6599672	Permian syenite	Probably sinistral stria	290	55	10W
Site 19	Sagdalen	553069	6599672	Permian syenite	Dextral stria	132	72	40E
Site 19	Sagdalen	553069	6599672	Permian syenite	Dextral stria	290	78	10E
Site 20	East of Haugnes	545887	6606845	Permian granite	Joint	72	85	
Site 20	East of Haugnes	545887	6606845	Permian granite	Joint	72	82	
Site 20	East of Haugnes	545887	6606845	Permian granite	Joint	60	89	
Site 20	East of Haugnes	545887	6606845	Permian granite	Joint	75	85	
Site 20	East of Haugnes	545887	6606845	Permian granite	Joint	125	85	
Site 20	East of Haugnes	545887	6606845	Permian granite	Joint	170	80	

Site 20	East of Haugnes	545887	6606845	Permian granite	Joint	165	85	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Brecciated zone	332	89	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	310	80	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	205	80	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	115	81	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	105	77	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	187	85	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	75	7	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	80	73	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	63	87	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	107	83	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	53	89	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	170	82	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	106	72	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	230	80	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	276	89	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Large joints making large scarps	170	80	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	70	70	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	176	85	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	90	10	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	91	50	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	45	10	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Joint	240	83	
Site 21	Jartkjær lake	546911	6608949	Permian granite	Striated fault	160	78	90
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	96	87	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	237	17	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	339	75	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	340	85	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	200	20	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	54	88	

Site 22	East of Sauar	547034	6601907	Permian granite	Joint	337	82	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	190	12	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	67	89	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	324	89	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	214	79	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	215	79	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	160	78	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	148	89	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	48	70	
Site 22	East of Sauar	547034	6601907	Permian granite	Quartz filled tension gash	330	80	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	96	77	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	18	56	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	247	72	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	187	13	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	315	51	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	282	81	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	246	89	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	325	52	
Site 22	East of Sauar	547034	6601907	Permian granite	Joint	334	73	
Site 22	East of Sauar	547034	6601907	Permian granite	Striated fault	14	58	90
Site 22	East of Sauar	547034	6601907	Permian granite	Striated fault	30	54	78N
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	324	84	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	220	61	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	326	84	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	252	70	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	236	78	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	330	85	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	225	70	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	323	80	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	242	75	

Site 23	East of Sauar	546749	6602405	Permian granite	Joint	212	87	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	48	89	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	196	68	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	320	78	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	350	86	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	190	87	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	241	84	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	236	83	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	234	73	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	160	88	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	325	85	
Site 23	East of Sauar	546749	6602405	Permian granite	Joint	228	89	
Site 24	Damvanna	548791	6604653	Permian granite	Joint	120	88	
Site 24	Damvanna	548791	6604653	Permian granite	Epidote-rich plane	250	66	
Site 24	Damvanna	548791	6604653	Permian granite	Epidote-rich plane	125	80	
Site 24	Damvanna	548791	6604653	Permian granite	Joint	302	88	
Site 24	Damvanna	548791	6604653	Permian granite	Joint	256	70	
Site 24	Damvanna	548791	6604653	Permian granite	Joint	309	89	
Site 24	Damvanna	548791	6604653	Permian granite	Joint	273	69	
Site 24	Damvanna	548791	6604653	Permian granite	Damage zone 20 cm wide	177	81	
Site 24	Damvanna	548791	6604653	Permian granite	Damage zone 20 cm wide	200	85	
Site 24	Damvanna	548791	6604653	Permian granite	Joint	103	79	
Site 24	Damvanna	548791	6604653	Permian granite	Joint	167	87	
Site 24	Damvanna	548791	6604653	Permian granite	Joint	85	89	
Site 24	Damvanna	548791	6604653	Permian granite	Joint	255	62	
Site 24	Damvanna	548791	6604653	Permian granite	Probably normal stria	263	64	70W
Site 24	Damvanna	548791	6604653	Permian granite	Probably normal stria	265	63	70W
Site 24	Damvanna	548791	6604653	Permian granite	Probably normal stria	258	64	70W
Site 25	Damvanna	548043	6604884	Permian granite	Felsic dyke	155	74	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	325	84	

Site 25	Damvanna	548043	6604884	Permian granite	Joint	315	84	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	165	77	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	172	77	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	270	85	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	173	83	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	260	89	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	117	86	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	68	89	
Site 25	Damvanna	548043	6604884	Permian granite	Tension gash	353	89	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	113	89	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	176	83	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	308	87	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	165	87	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	235	54	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	293	85	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	0	50	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	225	59	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	225	52	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	344	61	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	248	60	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	180	48	
Site 25	Damvanna	548043	6604884	Permian granite	Mafic dyke/vein	180	58	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	220	60	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	265	78	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	5	89	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	255	78	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	356	87	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	6	89	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	82	85	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	355	89	

Site 25	Damvanna	548043	6604884	Permian granite	Pegmatitic vein	107	40	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	264	73	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	255	83	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	300	78	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	13	40	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	218	52	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	4	40	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	299	82	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	0	42	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	72	89	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	14	34	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	226	77	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	250	73	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	338	89	
Site 25	Damvanna	548043	6604884	Permian granite	Normal fault zone	208	58	
Site 25	Damvanna	548043	6604884	Permian granite	Normal fault zone	208	55	
Site 25	Damvanna	548043	6604884	Permian granite	Joint	216	88	
Site 25	Damvanna	548043	6604884	Permian granite	Mafic dyke 3m wide sample 4	230	75	
Site 25	Damvanna	548043	6604884	Permian granite	Normal fault	200	59	70N
Site 25	Damvanna	548043	6604884	Permian granite	Striated fault	350	80	55S
Site 25	Damvanna	548043	6604884	Permian granite	Striated fault	160	83	70S
Site 26	west of Lindum	544189	660772	Permian granite	Large quartz vein	328	68	
Site 26	west of Lindum	544189	660772	Permian granite	Joint	34	68	
Site 26	west of Lindum	544189	660772	Permian granite	Joint	126	55	
Site 26	west of Lindum	544189	660772	Permian granite	Joint	134	80	
Site 26	west of Lindum	544189	660772	Permian granite	Joint	131	73	
Site 26	west of Lindum	544189	660772	Permian granite	Joint	326	78	
Site 26	west of Lindum	544189	660772	Permian granite	Joint	124	82	
Site 26	west of Lindum	544189	660772	Permian granite	Joint	119	82	
Site 26	west of Lindum	544189	660772	Permian granite	Joint	40	87	

Site 26	west of Lindum	544189	660772	Permian granite	Joint	42	86	
Site 26	west of Lindum	544189	660772	Permian granite	Joint	232	89	
Site 26	west of Lindum	544189	660772	Permian granite	Joint	48	89	
Site 26	west of Lindum	544189	660772	Permian granite	Joint	3	87	
Site 26	west of Lindum	544189	660772	Permian granite	Joint	95	66	
Site 26	west of Lindum	544189	660772	Permian granite	Joint	225	83	
Site 26	west of Lindum	544189	660772	Permian granite	Joint	239	82	
Site 26	west of Lindum	544189	660772	Permian granite	Joint	10	89	
Site 27	Lindum	543805	6601171	Permian granite	Joint	5	89	
Site 27	Lindum	543805	6601171	Permian granite	Joint	304	64	
Site 27	Lindum	543805	6601171	Permian granite	Joint	2	86	
Site 27	Lindum	543805	6601171	Permian granite	Joint	210	70	
Site 27	Lindum	543805	6601171	Permian granite	Joint	302	72	
Site 27	Lindum	543805	6601171	Permian granite	Joint	325	40	
Site 27	Lindum	543805	6601171	Permian granite	Joint	180	85	
Site 27	Lindum	543805	6601171	Permian granite	Joint	115	85	
Site 27	Lindum	543805	6601171	Permian granite	Joint	295	77	
Site 27	Lindum	543805	6601171	Permian granite	Joint	342	89	
Site 27	Lindum	543805	6601171	Permian granite	Joint	120	73	
Site 27	Lindum	543805	6601171	Permian granite	Large joint	0	70	
Site 27	Lindum	543805	6601171	Permian granite	Large joint	125	70	
Site 27	Lindum	543805	6601171	Permian granite	Joint	128	69	
Site 27	Lindum	543805	6601171	Permian granite	Joint	307	87	
Site 27	Lindum	543805	6601171	Permian granite	Joint	219	80	
Site 27	Lindum	543805	6601171	Permian granite	Joint	227	78	
Site 27	Lindum	543805	6601171	Permian granite	Joint	40	89	
Site 27	Lindum	543805	6601171	Permian granite	Joint	40	83	
Site 27	Lindum	543805	6601171	Permian granite	Joint	2	89	
Site 27	Lindum	543805	6601171	Permian granite	Joint	354	85	
Site 27	Lindum	543805	6601171	Permian granite	Joint	33	82	

Site 27	Lindum	543805	6601171	Permian granite	Joint	180	68	
Site 27	Lindum	543805	6601171	Permian granite	Joint	182	85	
Site 27	Lindum	543805	6601171	Permian granite	Joint	215	85	
Site 27	Lindum	543805	6601171	Permian granite	Joint	215	89	
Site 27	Lindum	543805	6601171	Permian granite	Joint	32	86	
Site 27	Lindum	543805	6601171	Permian granite	Joint	32	29	
Site 27	Lindum	543805	6601171	Permian granite	Joint	35	84	
Site 27	Lindum	543805	6601171	Permian granite	Joint	32	34	
Site 27	Lindum	543805	6601171	Permian granite	Joint	28	75	
Site 27	Lindum	543805	6601171	Permian granite	Joint	25	38	
Site 27	Lindum	543805	6601171	Permian granite	Joint	230	64	
Site 27	Lindum	543805	6601171	Permian granite	Joint	36	45	
Site 27	Lindum	543805	6601171	Permian granite	Joint	194	64	
Site 27	Lindum	543805	6601171	Permian granite	Joint	190	70	
Site 27	Lindum	543805	6601171	Permian granite	Joint	19	43	
Site 27	Lindum	543805	6601171	Permian granite	Joint	190	80	
Site 27	Lindum	543805	6601171	Permian granite	Joint	35	89	
Site 27	Lindum	543805	6601171	Permian granite	Joint	196	65	
Site 27	Lindum	543805	6601171	Permian granite	Joint	24	49	
Site 27	Lindum	543805	6601171	Permian granite	Joint	290	79	
Site 27	Lindum	543805	6601171	Permian granite	Joint	214	83	
Site 27	Lindum	543805	6601171	Permian granite	Joint	300	85	
Site 27	Lindum	543805	6601171	Permian granite	Joint	150	62	
Site 27	Lindum	543805	6601171	Permian granite	Joint	310	85	
Site 27	Lindum	543805	6601171	Permian granite	Joint	132	62	
Site 27	Lindum	543805	6601171	Permian granite	Joint	135	55	
Site 27	Lindum	543805	6601171	Permian granite	Joint	334	30	
Site 27	Lindum	543805	6601171	Permian granite	Joint	155	70	
Site 27	Lindum	543805	6601171	Permian granite	Joint	228	85	
Site 27	Lindum	543805	6601171	Permian granite	Joint	152	82	

Site 27	Lindum	543805	6601171	Permian granite	Joint	204	70	
Site 27	Lindum	543805	6601171	Permian granite	2 cm wide quartz-filled tension gash	335	89	
Site 27	Lindum	543805	6601171	Permian granite	Joint	352	35	
Site 27	Lindum	543805	6601171	Permian granite	Joint	160	73	
Site 27	Lindum	543805	6601171	Permian granite	Joint	220	34	
Site 27	Lindum	543805	6601171	Permian granite	Joint	205	30	
Site 27	Lindum	543805	6601171	Permian granite	Joint	350	34	
Site 27	Lindum	543805	6601171	Permian granite	Probably dextral stria	118	89	65W
Site 27	Lindum	543805	6601171	Permian granite	Probably dextral stria	115	82	64W
Site 27	Lindum	543805	6601171	Permian granite	Probably dextral stria	294	82	63W
Site 27	Lindum	543805	6601171	Permian granite	Probably dextral stria	297	89	64W
Site 27	Lindum	543805	6601171	Permian granite	Probably dextral stria	315	89	70W
Site 27	Lindum	543805	6601171	Permian granite	Striated fault	290	86	68W
Site 27	Lindum	543805	6601171	Permian granite	Striated fault	294	83	78W
Site 27	Lindum	543805	6601171	Permian granite	Striated fault	296	77	73W
Site 27	Lindum	543805	6601171	Permian granite	Striated fault	297	86	76W
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	290	89	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	166	77	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	172	61	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	269	85	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	156	70	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	178	72	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	270	82	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	330	89	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	90	73	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	340	89	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	198	82	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	163	80	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	275	80	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	335	89	

Site 28	Uleberg	549471	6597239	Permian syenite	Joint	185	30	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	160	47	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	250	70	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	252	79	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	171	67	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	255	71	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	177	71	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	241	80	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	173	72	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	170	65	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	189	58	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	176	78	
Site 28	Uleberg	549471	6597239	Permian syenite	Joint	280	80	
Site 28	Uleberg	549471	6597239	Permian syenite	Probably normal stria	180	75	83N
Site 28	Uleberg	549471	6597239	Permian syenite	Striated fault	193	77	81S
Site 28	Uleberg	549471	6597239	Permian syenite	Probably normal stria	201	50	60S
Site 28	Uleberg	549471	6597239	Permian syenite	Striated fault	170	72	80N
Site 28	Uleberg	549471	6597239	Permian syenite	Striated fault	183	78	76S
Site 28	Uleberg	549471	6597239	Permian syenite	Normal stria	165	64	82N
Site 28	Uleberg	549471	6597239	Permian syenite	Striated fault	162	78	80N
Site 29	Granheim	548666	6597865	Permian syenite	Joint	140	78	
Site 29	Granheim	548666	6597865	Permian syenite	Joint	186	80	
Site 29	Granheim	548666	6597865	Permian syenite	Joint	202	89	
Site 29	Granheim	548666	6597865	Permian syenite	Joint	202	83	
Site 29	Granheim	548666	6597865	Permian syenite	Joint	270	74	
Site 29	Granheim	548666	6597865	Permian syenite	Tension gash	145	80	
Site 29	Granheim	548666	6597865	Permian syenite	Joint	128	82	
Site 29	Granheim	548666	6597865	Permian syenite	Basaltic dyke 40 cm wide	120	70	
Site 29	Granheim	548666	6597865	Permian syenite	Basaltic dyke 40 cm wide	120	80	
Site 29	Granheim	548666	6597865	Permian syenite	Tension gash	180	78	

Site 29	Granheim	548666	6597865	Permian syenite	Tension gash	198	73	
Site 29	Granheim	548666	6597865	Permian syenite	Tension gash	3	80	
Site 29	Granheim	548666	6597865	Permian syenite	Tension gash	185	80	
Site 29	Granheim	548666	6597865	Permian syenite	Tension gash	194	82	
Site 29	Granheim	548666	6597865	Permian syenite	Tension gash	20	89	
Site 29	Granheim	548666	6597865	Permian syenite	Joint	134	80	
Site 29	Granheim	548666	6597865	Permian syenite	Tension gash	190	65	
Site 29	Granheim	548666	6597865	Permian syenite	Joint	140	68	
Site 29	Granheim	548666	6597865	Permian syenite	Joint	182	84	
Site 29	Granheim	548666	6597865	Permian syenite	Tension gash	12	63	
Site 29	Granheim	548666	6597865	Permian syenite	Joint	4	83	
Site 29	Granheim	548666	6597865	Permian syenite	Joint	306	88	
Site 29	Granheim	548666	6597865	Permian syenite	Tension gash	10	80	
Site 29	Granheim	548666	6597865	Permian syenite	Joint	310	89	
Site 29	Granheim	548666	6597865	Permian syenite	Tension gash	2	89	
Site 29	Granheim	548666	6597865	Permian syenite	Tension gash	200	82	
Site 29	Granheim	548666	6597865	Permian syenite	Tension gash	194	65	
Site 29	Granheim	548666	6597865	Permian syenite	Tension gash	1	89	
Site 29	Granheim	548666	6597865	Permian syenite	Tension gash	215	78	
Site 29	Granheim	548666	6597865	Permian syenite	Joint	140	66	
Site 29	Granheim	548666	6597865	Permian syenite	Striated fault	313	76	20W
Site 29	Granheim	548666	6597865	Permian syenite	Striated fault	180	80	64N
Site 29	Granheim	548666	6597865	Permian syenite	Striated fault	140	80	25N
Site 29	Granheim	548666	6597865	Permian syenite	Sinistral stria	200	80	70N
Site 29	Granheim	548666	6597865	Permian syenite	Normal stria	185	66	90
Site 29	Granheim	548666	6597865	Permian syenite	Normal stria	186	60	90
Site 29	Granheim	548666	6597865	Permian syenite	Normal stria	202	82	83N
Site 29	Granheim	548666	6597865	Permian syenite	Normal stria	198	79	87N
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Tension gash	300	78	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Metamorphic foliation	22	55	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Tension gash	295	74	

Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Tension gash	294	76	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	70	60	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	45	85	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Tension gash	304	81	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Metamorphic foliation	30	68	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	30	68	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	104	84	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Tension gash	295	84	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	194	40	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	310	89	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	298	85	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	160	80	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	110	84	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Metamorphic foliation	30	75	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	300	80	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Metamorphic foliation	28	58	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Tension gash	120	88	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Metamorphic foliation	37	64	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Metamorphic foliation	32	55	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Tension gash	280	81	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	158	80	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	285	64	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Metamorphic foliation	90	62	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	90	62	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Metamorphic foliation	68	62	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	68	62	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Calcite-filled tension gash	86	89	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	38	85	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	25	52	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	30	68	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	34	66	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	62	89	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Metamorphic foliation	30	61	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Joint	262	80	
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Probably sinistral stria	197	89	45E

Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Striated fault	122	55	90
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Striated fault	112	89	38S
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Normal stria	125	58	72S
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Normal stria	127	55	90
Site 30	Gomsrud	537695	6611763	Proterozoic banded amphibolites and gneiss	Normal stria	122	59	87N
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	165	58	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	20	28	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	43	31	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	286	78	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	206	78	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	290	86	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	182	58	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	292	70	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	172	68	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	305	38	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	156	89	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	320	84	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	300	24	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	172	72	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	188	43	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	187	54	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	288	70	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	304	30	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	182	60	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	315	58	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	180	60	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	320	60	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	176	70	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	172	68	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	140	89	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	214	75	

Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	295	52	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	143	84	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	182	58	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	90	89	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	326	30	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	181	75	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	110	88	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	260	26	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	306	78	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	185	63	
Site 31	Hagen	549495	6596178	Permian rhomb porphyry	Joint	185	67	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	155	60	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	285	88	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	253	18	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	175	84	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	270	77	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	178	80	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	222	80	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	166	72	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	282	17	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	271	89	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	280	11	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	270	85	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	148	84	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	163	75	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	220	83	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	266	83	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	337	65	
Site 32	Djupedal	551887	6595469	Permian rhomb porphyry	Joint	210	82	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Large joint	215	70	

Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	237	63	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	236	72	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	2	28	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	337	85	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	20	82	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	185	85	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	184	82	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	245	78	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	201	72	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	50	63	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	50	77	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	204	82	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	232	82	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	330	85	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	220	82	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	230	60	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	184	69	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	172	82	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	234	66	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	352	80	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	10	27	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	17	30	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	163	84	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	239	80	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	349	89	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	232	73	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	207	65	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	68	42	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	220	70	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	220	68	

Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	298	89	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	68	52	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	180	78	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	75	59	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	281	81	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	120	80	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	90	43	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	200	67	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	119	86	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	32	28	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	118	85	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	186	70	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	177	40	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	101	32	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	310	70	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	202	56	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	188	62	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	190	50	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	324	89	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	182	55	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	122	87	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	179	43	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	320	80	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	13	60	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	320	52	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	146	80	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	183	47	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	128	74	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	70	30	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	129	79	

Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	189	42	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	298	74	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	104	62	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	197	62	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	310	78	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	100	60	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	25	77	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	90	82	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	315	89	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	76	75	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	245	85	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	236	74	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	322	78	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	315	86	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	320	83	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	75	38	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	25	84	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	262	78	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	86	42	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	325	82	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	309	82	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	312	80	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	50	33	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	308	85	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	42	58	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	30	63	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	314	85	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	41	72	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	307	74	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	31	81	

Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	308	86	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	300	89	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	36	66	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	316	86	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	40	80	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	60	18	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	52	29	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	60	18	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Joint	53	19	
Site 33	Ulebergkollen	550230	6597756	Permian syenite	Striated fault	66	89	1E
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	10	70	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	154	84	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	34	80	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	216	65	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	209	73	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	330	82	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	87	73	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	80	80	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	119	81	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	194	60	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	180	82	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	280	47	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	355	87	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	320	72	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	120	78	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	140	68	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	155	64	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	203	80	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	274	73	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	328	89	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	198	65	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	350	89	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	20	85	

Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	216	70	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	322	73	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	15	88	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	336	89	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	197	79	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	148	86	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	322	63	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	140	86	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	340	65	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	206	70	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	308	89	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	96	87	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	185	82	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	145	84	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	200	86	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	294	77	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	297	78	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	310	78	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	190	81	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	134	77	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	67	62	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	328	77	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	189	88	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	314	80	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	50	54	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	192	85	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	300	74	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	288	80	
Site 34	Skollenborg	539794	6609543	Proterozoic gabbros, amphibolites	Joint	30	82	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Joint	270	45	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Joint	20	67	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Joint	166	72	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Joint	22	72	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Joint	242	48	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Joint	30	67	

Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Large joint	20	89	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Joint	33	74	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Joint	155	83	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Joint	330	86	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Joint	30	77	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Metamorphic foliation	30	77	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Joint	268	76	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Joint	20	78	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Joint	28	73	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Metamorphic foliation	28	73	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Joint	130	73	
Site 35	Gamlegrendåsen	536897	6612968	Proterozoic gabbros, amphibolites	Joint	116	64	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	322	78	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	180	38	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	154	85	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	126	80	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	330	84	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	197	38	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	204	28	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	310	80	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	130	86	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	320	85	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	25	38	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Metamorphic foliation	25	38	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	320	85	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	324	80	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	322	86	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	330	77	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	322	85	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	210	26	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	308	89	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	198	32	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	320	70	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	44	42	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	298	79	

Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	26	54	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Metamorphic foliation	26	54	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	308	75	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Metamorphic foliation	30	57	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	30	57	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	306	84	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	192	49	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	118	73	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Metamorphic foliation	22	63	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	22	63	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	321	89	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	325	88	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	132	83	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	125	79	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	230	55	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Tension gash	134	89	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Metamorphic foliation	30	62	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	30	62	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	235	53	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	20	64	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Metamorphic foliation	20	64	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	114	79	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	240	61	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	246	44	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	236	45	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	347	78	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	250	60	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	241	54	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	20	77	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Metamorphic foliation	20	77	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Metamorphic foliation	22	78	
Site 36	Gamlegrendåsen	537173	6613272	Proterozoic gabbros, amphibolites	Joint	22	78	

Appendix B

Sampling and thin section analyses

Sample	Localities	Site	UTM 32 easting	UTM 32 northing	Comment	Micro-fractures in thin section
1	Damvanna	Site 24	548791	6604653	Granite	No fractures- patches of prehnite
2	Damvanna	Site 25	548043	6604884	Inclusion of basalt into the granite	No fractures
3	Damvanna	Site 25	548043	6604884	Granite	No fractures- patches of prehnite
4	Damvanna	Site 25	548043	6604884	Dyke of basalt, 3 m wide, N230/75	No fractures
R1	Reineelva	Site 4	554151	6596841	Coarse grained syenite	Patches and some diffuse veins of prehnite
R2	Reineelva	Site 4	554151	6596841	N-S dyke of basalt	No fractures
1K	South of Øvre	Site 1	548704	6595854	Basalt	Few open fractures
2K	South of Øvre	Site 1	548473	6595838	Syenite	Many open cracks with brownish alteration at the borders
3K	Solum	Site 2	551392	6595645	Basaltic dyke 10 cm wide, 005/85 into rhomb porphyries (many dykes at this site, all trending N005 to N010 and 50 cm wide max)	No fractures
4K	Hvittingfoss	Site 3	556815	6593323	Basaltic dyke 50 cm wide, N170/90 into syenites	Numerous sealed fractures filled with prehnite with high angle cross-cutting relationships
5K	Sagdalen	Site 11	553056	6599477	Basaltic dyke (among many others) into syenites N120-N130/80, 1 m wide	Parallel set of quartz-filled tension gashes
6K	Sagdalen	Site 11	553056	6599477	Basaltic dyke (among many others) into syenites N145-N160/80, 2 m wide	No fractures
7K	Sagdalen	Site 12	552960	6599779	Basaltic dyke into syenites N170/75- N160/90, 1 m wide	Many open cracks with brownish alteration at the borders
8K	Sagdalen	Site 13	552420	6598347	Basaltic dyke into syenites N150-N160/90, 5 m wide	Many open cracks with brownish alteration at the borders