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Äspö Hard Rock Laboratory

Local model of geological structures close to the F-tunnel

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April 2002

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Abstract

This work presents a 50m scale structural model of the HQ-3 Area, with connections to surrounding structures via a 200 m scale model. In the area, rock stress measurements have been carried out near the F-Tunnel (TASF), in two boreholes. The model is mainly based on data from SKB's database, SICADA and on three SKB reports. In the rock mass, massive granodiorite is the most common rock type, with subordinate granite and aplite slabs and veins, and also mylonite. A dominant structure, Zone Z4, and a water bearing fracture swarm, NW-hyd intersect the models. The 50 m scale model also demonstrates a number of single joints, based on indications in two boreholes. Stereographic joint plots demonstrate a difference between borehole data and tunnel data, which may be due to partly borehole directions, partly to different tunnel mapping methods.

Sammanfattning

I detta arbete presenteras en strukturell modell av ett bergblock med ca 50 meters sida. Det modellerade området ligger invid F-tunnelns norra sida. Geologiska strukturer inom modellblocket förbinds med omgivande bergmassa via en modell med 200 m sida.Inom området har bergspänningsmätningar utförts i två borrhål, med olika metoder. Modellen har gjorts med SKBs modellverktyg RVS som bygger på Microstation.

Modellen baseras på data från SKBs databas SICADA samt tre SKB rapporter. 50 meters blocket baseras på två borrhål inom blocket samt F-tunneln. 200 metersblocket baseras på långa sträckor av karterade tunnlar (A, F, G, I, J), Schakt H och flera borrhål.

Granodiorit är den vanligaste bergarten inom området som även inehåller underordnade kroppar och gångar av aplit, granit och mylonit. Vissa partier av granodioriten är folierade.

En dominerande struktur, Sprickzon z4, och en vattenförande spricksvärm, NW-hyd, skär modellblocken. Z4 har även observerats i TBM tunneln, sektion 3520 och i skärningen mellan F-tunneln och I-tunneln, samt i borrhål och i delar av nedfartsrampen. Z4 antas vara en gren av en större zon, NE-2. Spricksvärmen NW-hyd har också observerats i TBM tunneln, sektion 3400-3500. 50 metersblocket innehåller även några enstaka sprickor, varav flera subhorisontella, baserade på indikationer i de två borrhålen. Samtliga sprickriktningar återfinns i F-tunneln och övriga omgivande tunnlar.

Stereografiska plottar från 200 m modellblocket visar på stor skillnad mellan sprickdata från borrhålen och data från tunnlar och schakt. Detta antas bero dels på en snedfördelning av borrhålens riktning, dels på skilda metoder för tunnelkartering och dels på att tunnlar och schakt endast går i tre riktningar, lodrät och två horisontella, medan flera av borrhålen lutar.

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1 OBJECTIVE

The Äspö HRL (Hard Rock Laboratory) has been designed as part of developing a deep repository for nuclear waste fuel (Rhen et al 1997). The laboratory is located on of Äspö Island, North of Oskarshamn, in South-east Sweden, and situated in Precambrian bedrock, at a depth of 450 metres below sea level. The access ramp forms a spiral down to the laboratory level. In the HRL, test methods are studied, and tests and studies are carried out with respect to geology, tectonics, hydrogeology, hydraulics, geochemistry, groundwater chemistry, rock mechanics, support methods, etc.

The aim of this work is to present a 50m scale structural model of the HQ-3 Area, to the North of the F-tunnel, with connections to surrounding structures. In the model area, two boreholes, have been drilled. KF0093A01 has been drilled from the TASF tunnel almost horizontally, 36 metres of length towards the Northwest. KA2599G01, 129 m of total length, has been drilled from NASA2497A, near ramp TASA, ch. (chainage) 2600 m, at level -344 m, and plunges steeply downwards, also with a north-westerly bearing. Tunnels and boreholes are shown in Figure 1.

Rock stress measurements, carried out in KF0093A01 comprise hydraulic fracturing at 21-32 m and overcoring at 29-36 m, and in KA2599G01 at 105-123 and 107-129, respectively (Christiansson et al., in progress). The tests are included in a series of site investigations, planned as part of the Swedish nuclear waste disposal programme. Design work will be carried out as a base for studies of Constructability, Environment Impact Assessment and Safety Assessment. State of stress and rock mass strength are two key parameters to determine the risk for spalling at large depth. Within the scope of work to provide necessary rock mechanics support for the site investigations, the Swedish Nuclear Fuel and Waste Management Co (SKB) has studied some of the available equipment's for *in-situ* stress measurements. A project with the objective to compare three different equipment's for *in situ* stress measurements under similar conditions has been carried out. The measured results could be verified against known conditions at the Äspö HRL.

2 BACKGROUND DATA

The following documents and computer files constitute the foundation of the present work.

- Microstation (dgn) files, showing the Äspö Tunnel Complex and their lithology, supplied by SKB.
- The RVS model of the Prototype Storage Area has been viewed.
- Data from SICADA, as shown in *Table 1* and *Table 2*.
- Excel files supplied by SKB, with fracture orientation data from tunnels as shown in *Table 3*.
- Rhén I (Ed), 1995. Documentation of Tunnel and Shaft Data, Tunnel Section 2874-3600m, Hoist and Ventilation Shafts 0-450m. Rhén 1995. SKB. Stockholm.
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Table 1 Data from SICADA used for stereographic projection and for discontinuities in the 200 m model. SICADA files ”width” include orientation data, rqd is Deere’s Rock Quality Designation, and ”struc” files show shear indications such as mylonite and breccia.

Borehole	total length	from	to	SICADA data type	Stereogr. proj.	Discontinuity indication
KA2162B	288.1	243	288.1	width	Yes	No
KA2563	363.43	17	72	width	Yes	No
KA2598A	300.77	0	160	width, rqd, struc	Yes	high rqd, shear
KA2599G01	129.12	0	129.12	width	Yes	No
KA3191F	210.41	165	210.41	width	Yes	No
KA3385A	34.18	0	10	width	Yes	No
KA3510A	150.06	0	57	width, struc	Yes	mylonite
KA3539G	30.01	2	30.01	width	Yes	No
KA3542G02	30.01	1	30.01	width	Yes	No
KAS04	480.98	427	480.98	width, rqd, struc	Yes	high rqd
KF0051A01	11.43	0	11.43	width	Yes	No
KF0093A01	36.04	0	36.04	width, struc	Yes	foliation
KG0021A01	48.82	0	48.82	width	Yes	No
KJ0044F01	17.26	0	17.26	struct	No	mylonite
KJ0050F01	46.45	0	46.45	width	Yes	No

Table 2 Data from SICADA used for stereographic projection and for discontinuities in the 50 m model. SICADA files "width" include orientation data, and "struc" files show shear indications such as mylonite and breccia.

Borehole	total length	from	to	SICADA data type	Stereogr. proj.	Discontinuity indication
KF0093A01	36.04	0	36.04	width, rock	Yes	joints, foliation
KA2599G01	129.12	80	129.12	width, rock	Yes	joints
KF0051A01	11.43	0	11.43	width	Yes	no relevant data

Table 3 Tunnel data used for stereographic projection

ID	Engineered structure	Trend/plunge	Chainage	length, m	No of fractures
TASA	Access ramp	10/8	2625-2700	75	202
TASF	F-tunnel	75/7	0-75	75	222
TASG	G-tunnel	98/1	0-60	60	296
TASH	Hoist shaft	104/89.8	350-450	100	38
TASI	I-tunnel =TASN3507	356/2	all	ca 25	52
TASJ	J-tunnel	175/2	all	ca 50	22

3 ASSUMPTIONS AND CONCEPTS FOR INTERPRETATION

For interpretations of discontinuous structures, the following assumptions have been used:

- Observations in tunnels represent a much bigger exposed trace of a structure than do borehole logs, and give indications on structure persistence, and directly or indirectly whether or not a discontinuity terminates towards another.

- Zones featuring shear characteristics are generally regarded as more continuous than other structures.

- Discontinuity indications in boreholes, the extension of which fit between two boreholes, have been regarded as indications of the same structure. Closely spaced indications are regarded as more reliable indications of the same structure than indications farther spaced.

- If indications in two boreholes are far spaced, the discontinuity is interpreted to terminate towards a structure with its indications closer spaced (cf. above)

- Many discontinuity indications with the same direction indicate that these joints may not just be more frequent but also more persistent than random indications, therefore, they have been interpreted to persist until they meet another structure.

4 SCOPE OF WORK

Two models were created: one at scale 200 m, and another at scale 50 m (cf. Figure 1). RVS Master system RT 38_RH00 co-ordinates of the models are shown below, and model locations are shown in Figure 1.

Model block	origin E	Origin N	Origin Z	width dx	length dy	dz	y-axis bearing
200m	1551213.0	6367730.0	-350	200	200	-200	348.2
50m	1551295.0	6367804.5	-430	50	45	-45	346.0

The 200 m scale model is based on tunnel mapping as reported in three SKB reports: Rhen (ed.) 1995, Stanfors et al. 1994, Rhen (ed.) 1997, and on drill cores as listed in *Table 1*. It aims to identify structures, which extend through and beyond the 50 m scale model and to be used as a basis for that model.

The 50 m scale model is based on the 200 m scale model with respect to larger structures. Modelling of single joints is based on two boreholes partly or entirely within the model block, KA2599G01 and KF0093A01. Only joints labelled as natural joints in the core log data from SICADA have been used for the model (parameter "width").

The two stress measurement boreholes lie entirely within the 200 m scale model, except for the top five metres of KA2599G01. A number of other boreholes lie entirely or partly within the 200 m model block, as shown in Figure 1.

KF0093A01 also lies entirely within the 50 m scale model, while KA2599G01 enters the top boundary of the model at 86.9m, with its lower part in the model. Another, short borehole, KF0051A01 also lies within the 50 m scale model, but have only been used for rock type, as no relevant discontinuity data exists for this borehole. The far end of Borehole KJ0050F01 intersects the North-western corner the model.

5 ROCK TYPES

Within the 50 m block, KA2599G01 lies within massive granodiorite. The upper part of the core also include a few 1 to 5 metres thick occurrences of aplite and mafic volcanics.

KF0093A01 is drilled in granodiorite with a subordinate occurrence of about 1 metre of fine-grained granite (or aplite) at 30 m. As no aplite has been observed in KA2599G01, the aplite is interpreted as being minor and orientated more or less in vertical slabs. There are several minor such occurrences in the adjacent tunnel, TASF, but no certain correlation can be made, as all these appear to terminate within the tunnel. The rock structure is massive, except from 30.59 m to the end at 36.05 m, where the rock features a schistose structure (cf. Chapter 6.1).

In the tunnels and the other boreholes within the 200 m model, granodiorite is the most abundant rock type. Some granite occur, as well, as subordinate slabs and veins of aplite and pegmatite, and also mylonite at a few locations. Pegmatite and mylonite have not been observed within the 50 m model, but there is no reason to assume that these rock types would not occur in additional boreholes or tunnels.

6 FRACTURES AND FRACTURE ZONES

Zone NE-2 (Rhén et al.1997) occur in the upper Southeast corner of the 200 m scale model block (disc in Figure 2), and two more zones, Zone Z4 and NW-hyd are also included. The latter two zones plus 5 single joints are included in the 50 m scale model, as shown in ***Figure 3*** and ***Figure 4***, and specified in *Table 4*.

Table 4 Zones and Joints in Area HQ3 (both models).

ID	**Mapped occurrences in Tunnels (TA...) or borehole (K...)**	**ID or description, width, minerals**	**Orientation**	**Data source**
Zone Z4	TASA ch 3520	Fracture Zone Z4	NE sub-vert.	PR 259528
	TASF –TASJ junction	Fracture Zone	NE sub-vert.	PR 259528
	TASA ch 2740	Fracture Zone Z2	NE steep SE	PR 259419
	KAS 13,	RQD<25	no data	SICADA
	KA3010, 22.87-25.00m	mylonite	no data	SICADA
	KA 2598A , 70-76m	RQD<25, incr fract, breccia (106) & tect (108)	no data	SICADA
	KF 0093A01	foliation at end of hole	no data	SICADA
	KJ 0044F01	mylonite and increased fracturing at end of hole	no data	SICADA
NW-hyd	TASF ch 60-70	Zone w 4 parallel water bearing fractures	NW sub-vert.	PR 259528
J2	KF 0093A01, 16.25m, 323/80 KA 2599G01, 90.14m, 325/76	granodiorite, 1-2 mm, r, ep cl ca	NNW/steep East	SICADA
J1	KF 0093A01, 29.28m, 355/47 KA 2599G01, 109.46m, 347/35	granodiorite, 1mm, r, cl	N/moderate East	SICADA
H1	KA 2599G01, 111.99m	granodiorite, 1mm, r, cl	93/17	SICADA
H2	KA 2599G01, 120.64m	granodiorite, 1mm, r, cl ca	55/7	SICADA
H3	KA 2599G01, 125.67m	granodiorite, 1mm, s, cl ca	23/2	SICADA
abbrevistions: r=rough, s=smooth, ep=epidote, ca=calcite, cl=chlorite				

6.1 Zone z4

Zone z4 is the most dominant structure in the model. (cf. Figure 2). It strikes Northeast and dips almost vertically with minor dip variations towards the Southeast and Northwest. Zone z4 appears to bifurcate with NE-2 (cf. Rhén et al.1997, p 138) south of the ramp (ch. 2750) and above it (near ch. 1600-1800 m).

All other discontinuities are interpreted to terminate towards this zone due to its shear-zone character. (In the tunnels “fracture zones” are defined to feature shear characteristics while zones without such indications are labelled “increased fracturing”, cf. Rhén et al.1997, p43). Zone Z4 has been mapped crossing TASA at ch. 3520, for 20 m at the bifurcation between the tunnels TASF and TASJ, and in borehole KA3510A, fitting with the TASA ch 3520 record. For reasons unknown to the Authors, this zone does not occur in the RVS computer model of the prototype storage, other than as a single joint crossing TASA at ch. 3520, while the tunnel map shows a 5 m wide fracture zone (z4) at that location (Rhen et al 1997). The following data indicate that the zone extends further Northeast into and beyond the 50 m scale model block.

- KJ0044F01: Mylonite at ch. 16.70 – 17.26 m (end of borehole) and increased joint frequency from ch. 15 m.
- KF0093A01: The rock (granodiorite) is schistose from ch. 30.59 m to the end at ch. 36.05 m.
- In the ramp (TASA) at ch. 2740 m, occurs a fracture zone labelled z2 (Stanfors et al. 1994, p 50) with a similar strike but with a slightly different dip. The position and orientation fits fairly well with the other observations of z4.
- Low RQD and increased fracture frequency at expected depth in KAS 13, and also breccia and unspecified tectonic structure in KA 2598A).

6.2 NW-hyd

This zone is not a fracture zone by strict definition, but four parallel, water-bearing joints (part of a "fracture swarm", Rhén et al.1997, p 43), mapped within a 10 m stretch of TASF (ca 60-70 m from TASJ) adjacent to the south part of that tunnel (Rhén et al.1997, pp 138-139). The South part of TASF, from where KF0093A01 has been drilled, is reported as unmapped (Rhén 1995, p 37). A number of joints with north-westerly strike occur also in Borehole KJ 0044F01, but at chainages, which do not match with the extension of those mapped in Tunnel TASF, within the 50 m model block. Also, KJ0050F01 features intense jointing in the beginning of the borehole, but low jointing at length. Furthermore, Zone z4 is mapped as a "fracture zone" (Rhén 1995, p 11 and p 36-37) and thus defined as a shear zone or fault (Rhén et al.1997, p 43), For these reasons, the joints of Zone NW-hyd have been interpreted to terminate at Zone Z4 (***Figure 3***). Water bearing joints with NW strike also exist in TASA, ch. 3400-3450 (Rhén et al.1997, p 138-139) and fit quite well with those mapped in TASF. A parallel to NW-hyd exist West of the 50 m scale model, as shown in Figure 1.

6.3 Joints J1 and J2

Two joints in the model, J1 and J2 feature indications in Boreholes KF0093A01 and KA2599G01. Several joints with the same orientation as J1 occur in TASF and TASJ (Rhén 1995, p 36-37), while J2 is almost parallel to NW-hyd, although not water-bearing in the boreholes. The extrapolation of J1 would cross the TASF Tunnel at ch 70 m, but there is no fitting joint on the tunnel map (Rhén et al 1995). Thus J1 has been interpreted to terminate towards NW-hyd, in addition to Zone Z4 (cf. ***Figure 3***). A joint with the same strike exist in the tunnel at ch 60, but is much steeper, does not fit when extrapopated, and has thus been interpreted to be another joint, maybe intersecting the downhole end of KA2599G01.

Tunnel TASF is reported to be unmapped from ch 70 m, and up, so it is unknown whether J2 extends to the tunnel. J2 may cross J1, but has in the model been interpreted to terminate also to J1 as:

- J1 indications in the two boreholes are close to each other, and are thus regarded to be more certain indications of one joint, while the two J2 indications are spaced some 20-m apart (cf. ***Figure 4***). Therefore, J2 may well be two different joints.

6.4 Sub-horizontal joints

Three sub-horizontal joints in KA2599G01 have been included in the model:

- H1, H2 and H3. (A few more exist, but have been omitted as they obstruct the view of the model. One lies between H1 and H2 and appears to bifurcate to both. Another one is located below H3 and may constitute a branch of that joint).

All sub-horizontal joints are interpreted to persist until they terminate towards Zone Z4, NW-hyd and J1 (***Figure 3*** and Figure 4) as:

- Sub-horizontal indications are abundant in Borehole KA2599G01, and thus interpreted to persist.
- No sub-horizontal joint indications occur in KA2599G01 above J1, within the model.
- Gently dipping joints mapped in TASF generally terminate towards Zone Z4 and NW-striking joints.

6.5 Other joints

A number of other joints of various directions occur in the two boreholes, but none of them can be correlated between the boreholes. For this reason they are regarded as being short and only shown in the model as discs (Figures 3 and 4). Some of them may, however, continue and terminate towards the other joints.

7 CONCLUSIONS AND STRUCTURAL MODEL

The rock mass in the 50 m model appears to be representative also for the 200 m model with respect to rock type and also with respect to joint distribution, except for certain north-south striking joints which do not occur in the 50 m model, in spite of the directions of boreholes KA2599G01 and KF0093A01.

A summary of the main structures, and their occurrence in the two models are shown in Figure 1. Zone Z4 is the most dominant structure, verified in the tunnels and in Borehole KA3510A, and supported by indications in boreholes KAS04, KJ0044F01, KF0093A01, KJ0050F01 and TASA, ch 2740m. A parallel to the fracture swarm NW-hyd, occurs West of the 50 m scale model. It appears to be more intense Northwest of Zone Z4 in three boreholes and less in the tunnel south thereof, while NW-hyd terminates towards Zone Z4, which may indicate that NW hyd could be displaced by Zone Z4. Further single joints, several of which are subhorizontal, are shown in the 50 m scale model (***Figure 3*** and ***Figure 4***). The relationships between the structures are as follows:

- Zone Z4 is the dominant structure, towards which NW-hyd, J1, J2, H1, H2, and H3 terminate.
- J1 also terminates towards NW-hyd
- H1, H2, and H3 also terminate towards NW-hyd and J1
- J2 terminates towards J1

All available Sicada fracture orientations within the 200 m model (14 borehole sections) have been plotted in stereonet using the Rocscience software DIPS. ***Figure 5*** shows a plot of the boreholes used. Figure 6 and Figure 7 show pole and contour plots, respectively, of almost 1400 joints in boreholes within the 200 m scale model. Figure 8 and Figure 9 show contour and pole plots, respectively of more than 900 fractures observed in Tunnels TASA ch 2625-2700 m, TASF, TASG, TASI, TASJ, and in the hoist shaft (TASH). The contour plots show a significant deviation between the two data sets, the tunnel data showing a strong concentration of subhorizontal joints while the borehole data show concentrations of North-South striking joints with moderate dip mainly towards the West. A check of the orientations in the borehole Sicada data has confirmed more than 300 joints within NS +/- 20 degrees, about 25%, corresponding to the pole concentrations.

Most of the borehole lengths are drilled outside of the tunnels from where tunnel data has been taken, and the deviation may be due to this. However, a plot of borehole lengths versus borehole trend (cf

Figure 10) indicates, that a large amount of borehole length (KA2162, KA2563, KA2598, KA3191) is oriented West-northwest, and may cause an over-representation of NS striking joints. There is also a defeciency of sub-vertical borehole length, 10 per cent only (KA2599G01 and KA3539G), causing a corresponding lack of intersections with horizontal joints (cf Figure 11). Furthermore, the shaft and tunnels used, run in three directions and may thus disfavor joints.

Nevertheless, a comparison of pole plots of borehole data and tunnel data (Figure 6 and Figure 9) show that a wide range of orientations exist in both sets, and that there is a large number of sub-horizontal joints also in the borehole data set. Moreover, the boreholes show a much wider distribution of joint orientations, which may be due to the much larger number of data.

Data from Boreholes KF0093A01 and KA2599G01, within the test volume are too few to carry out a significant statistical comparison, but pole plots (cf. Figure 12 and Figure 13) do not appear to indicate any significant deviation from the 200 m model distribution, except for the absence of NS/approx 45, which show a concentration in the 200 m model.

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Figure 1 *Map of model area, showing 200 m and 50 m model boundaries as well as structures, tunnels and boreholes, referred to in the report. The two light blue shaded zones are not fracture zones by strict definition, but so-called "fracture swarms" with NW striking water-bearing fractures.*

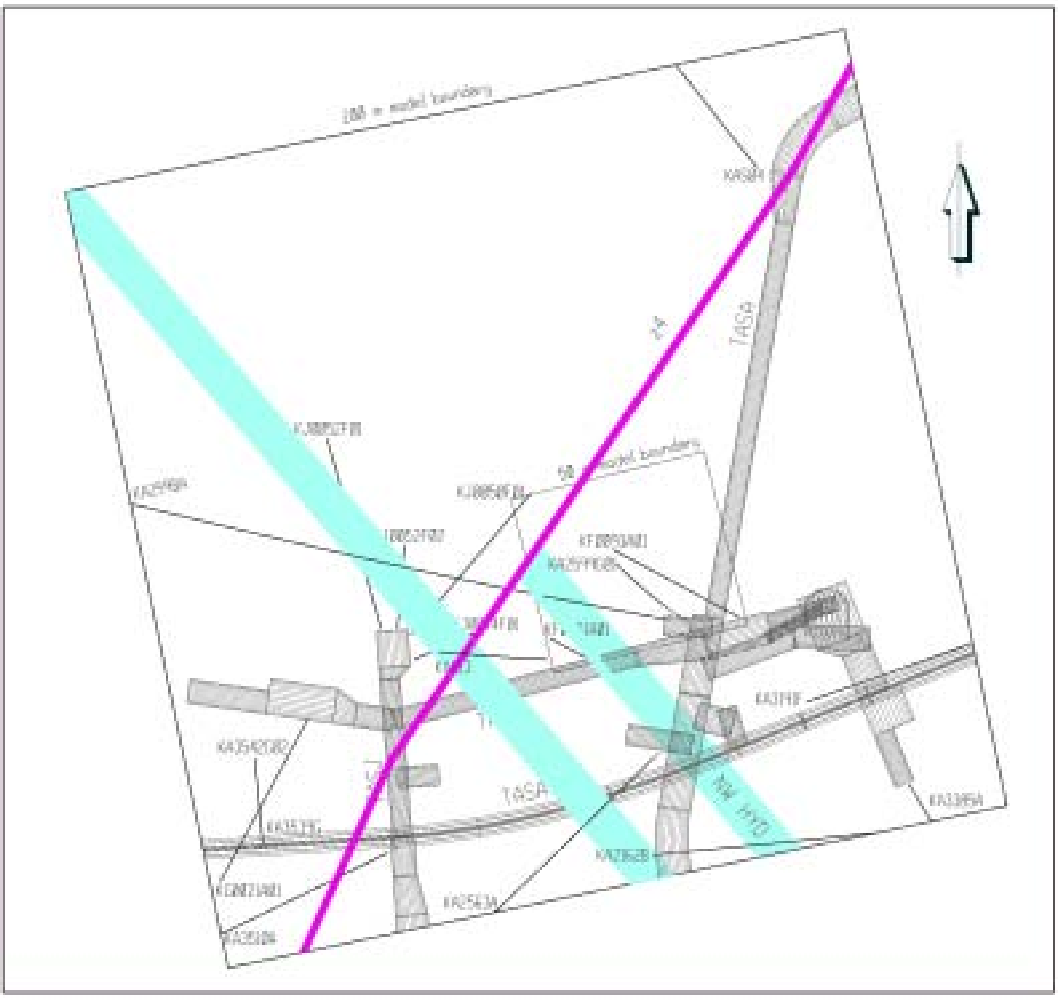


Figure 2 *Structural 200 m scale model showing Zone Z4 and its indications (two of the discs) in tunnels. The other discs to the right are interpreted as indications of NE-2 (Rhén et al. 1997). The disc to the left is z5 (Rhen 1995), a parallel to z4. Both zones appear to be branches of NE-2.*

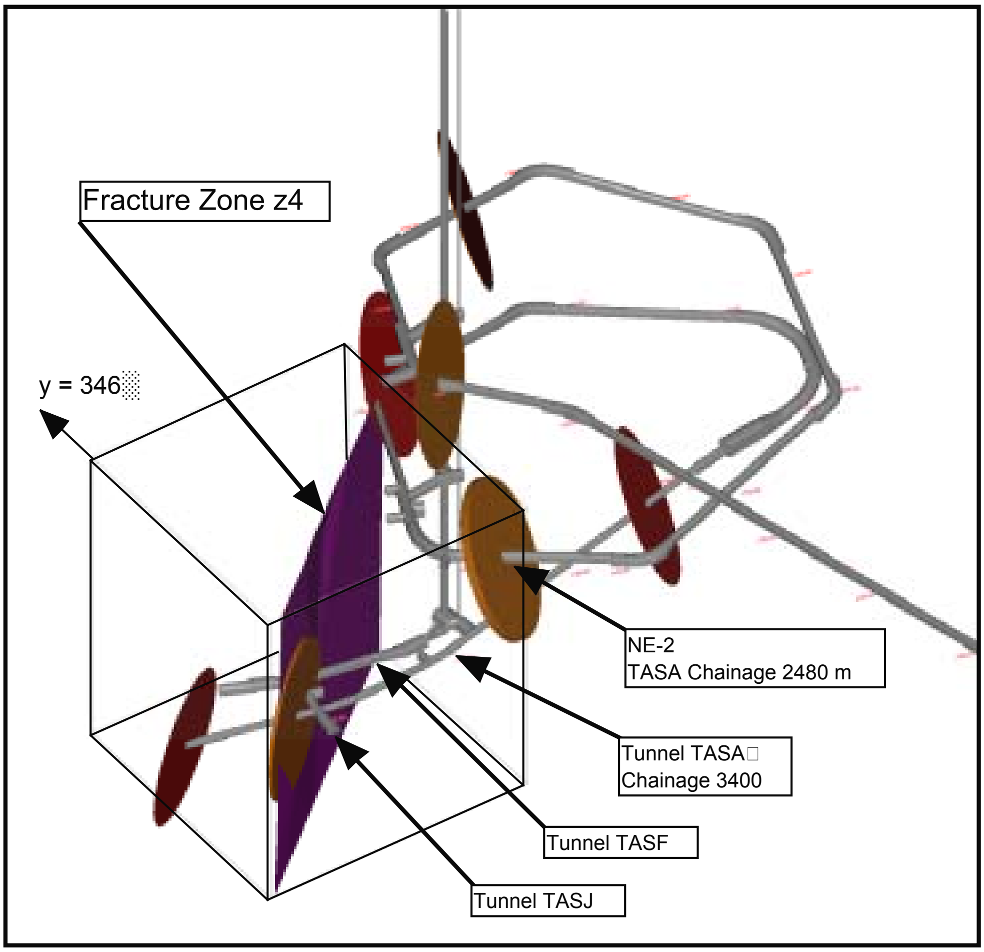


Figure 3 *Structural 50 m scale model. Map at level –455, intersection of boreholes KA2599G01 and KF0093A01. The light blue shaded zone is not a fracture zone by strict definition, but part of a so-called "fracture swarm", observed as four NW striking water-bearing fractures in the F-tunnel.*

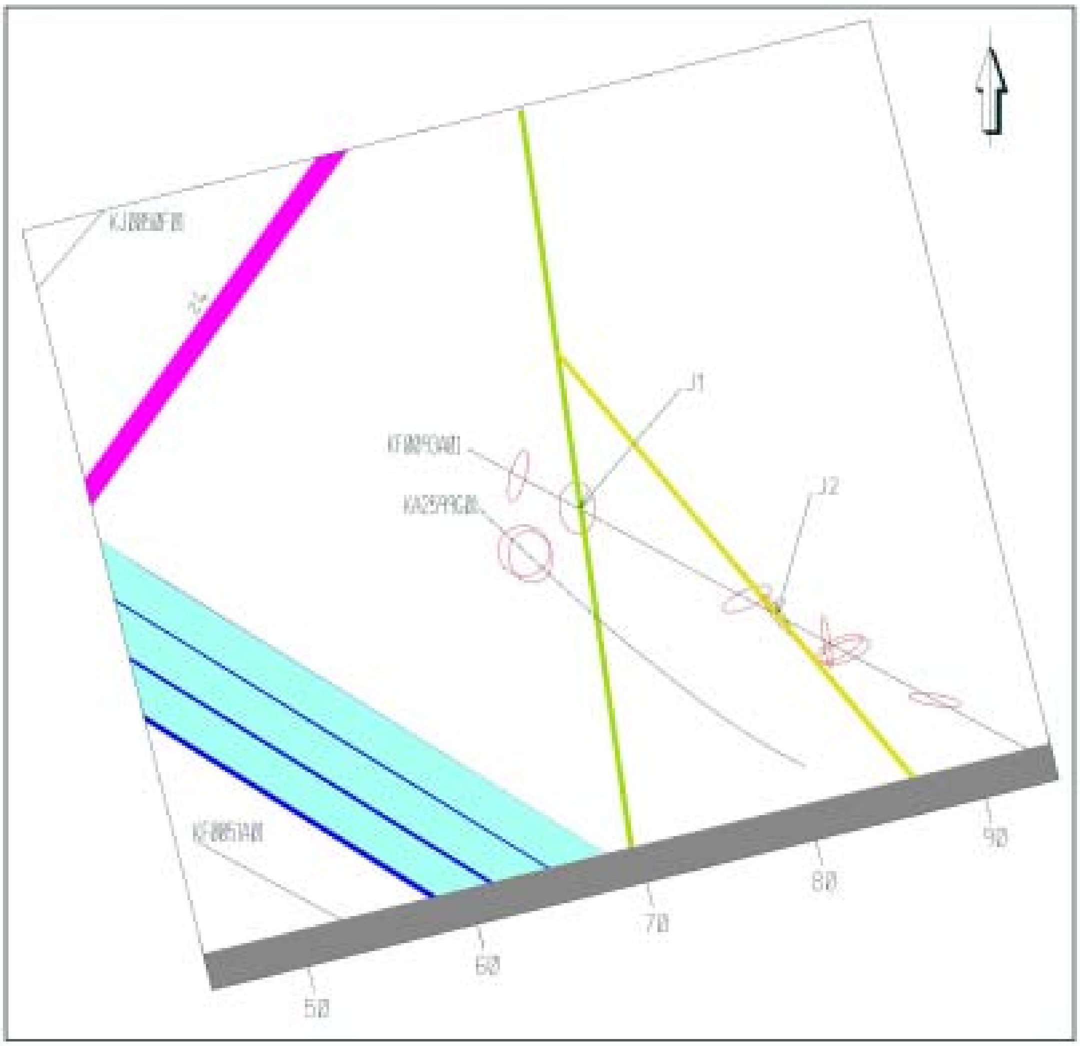


Figure 4 *Structural 50 m scale model. Section in vertical plane along boreholes KA2599G01 and KF0093A01. View from the SW, athwart fracture swarm NW-hyd.*

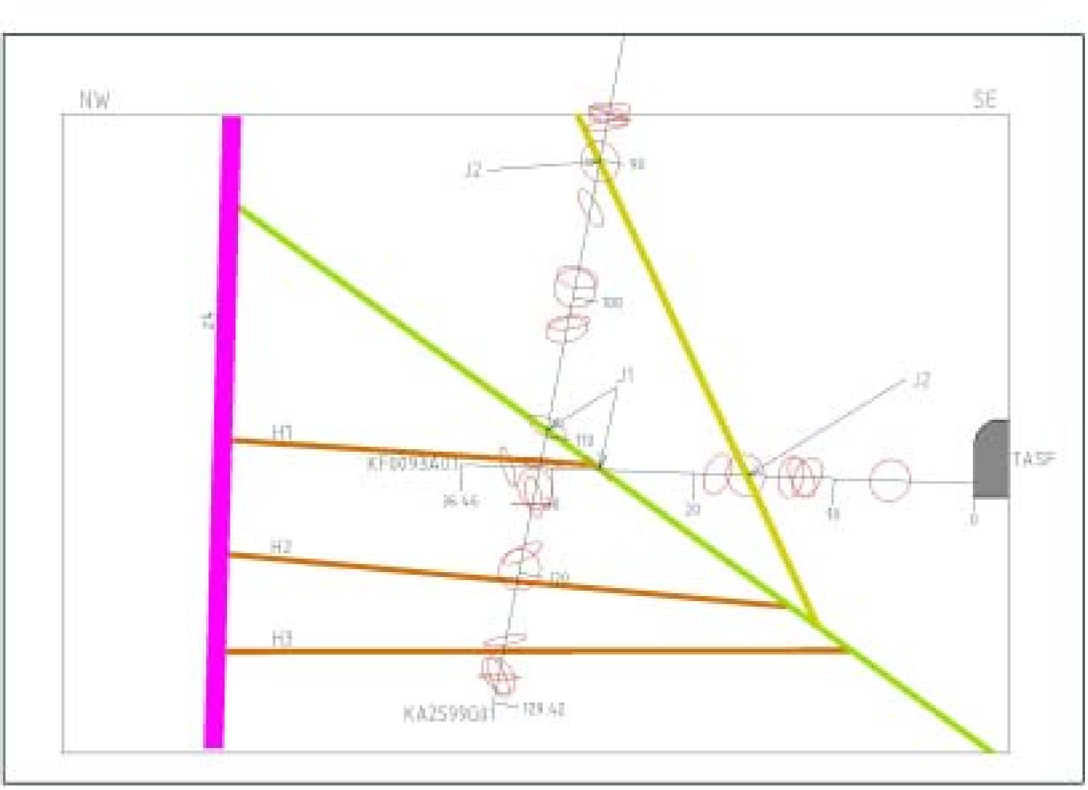


Figure 5 *Stereonet plot of Boreholes in the models. "Others" are indicated in the plot.*

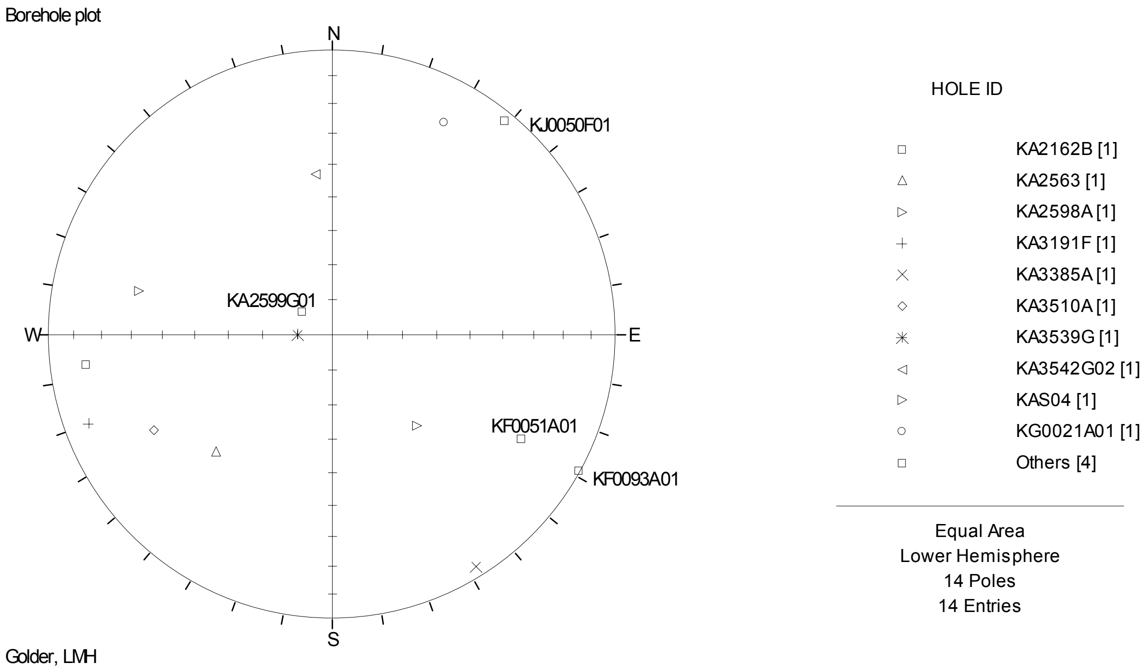


Figure 6 *Stereonet pole plot of joints in the 200 m scale model. "Others" = KA3385A, KA3539G, KA3542G02, and KG0021.*

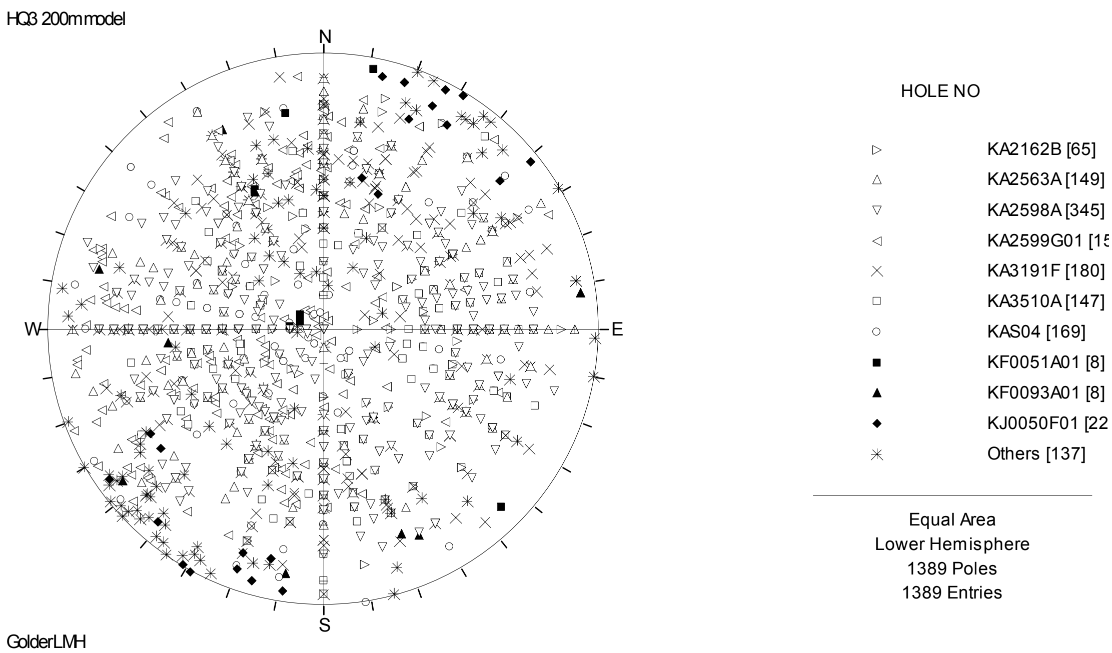


Figure 7 *Stereonet contour plot of joints in the 200 m scale model.*

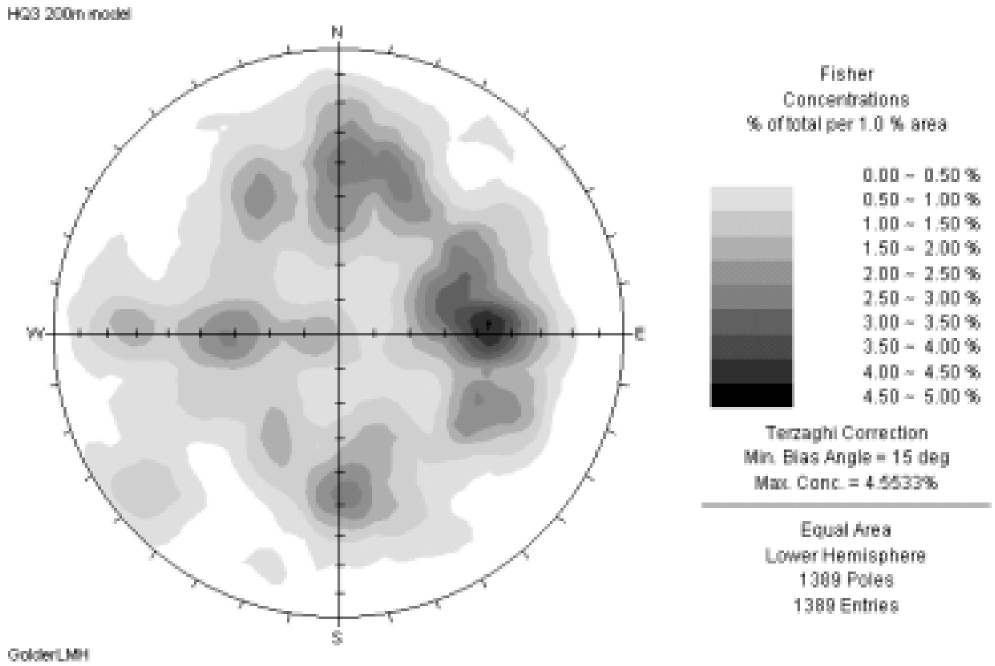


Figure 8 *Stereonet contour plot of joints in Tunnels TASA ch 2625-2700, TASF, TASG, TASI, TASJ, and hoist shaft (TASH) from elevation -350 metres to bottom at elevation –450 metres.*

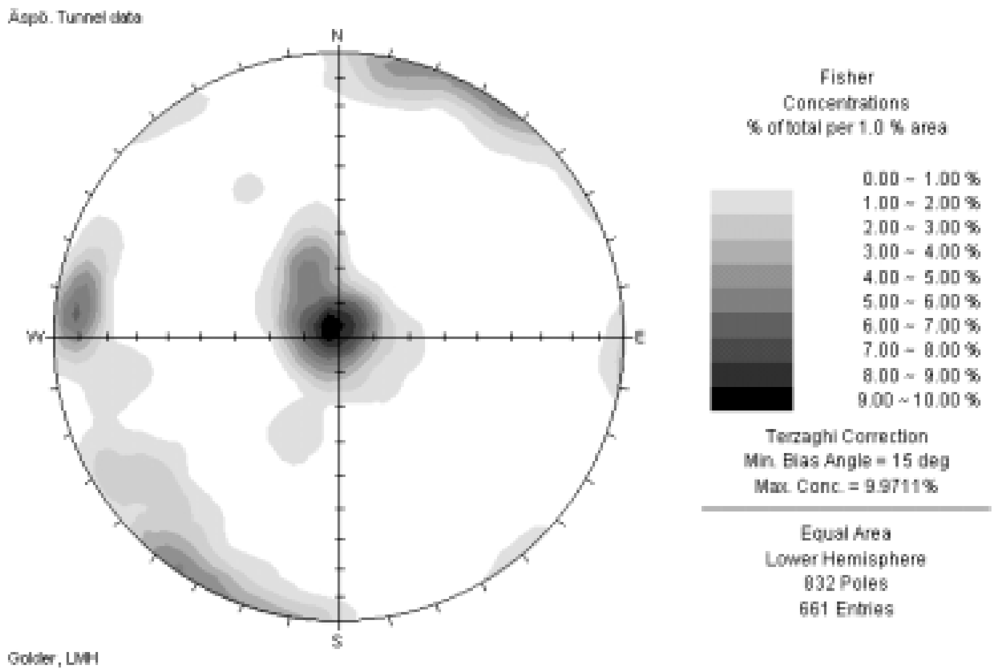


Figure 9 *Stereonet pole plot of joints in Tunnels TASA ch 2625-2700, TASF, TASG, TASI, TASJ, and hoist shaft (TASH) from elevation -350 metres to bottom at elevation –450 metres.*

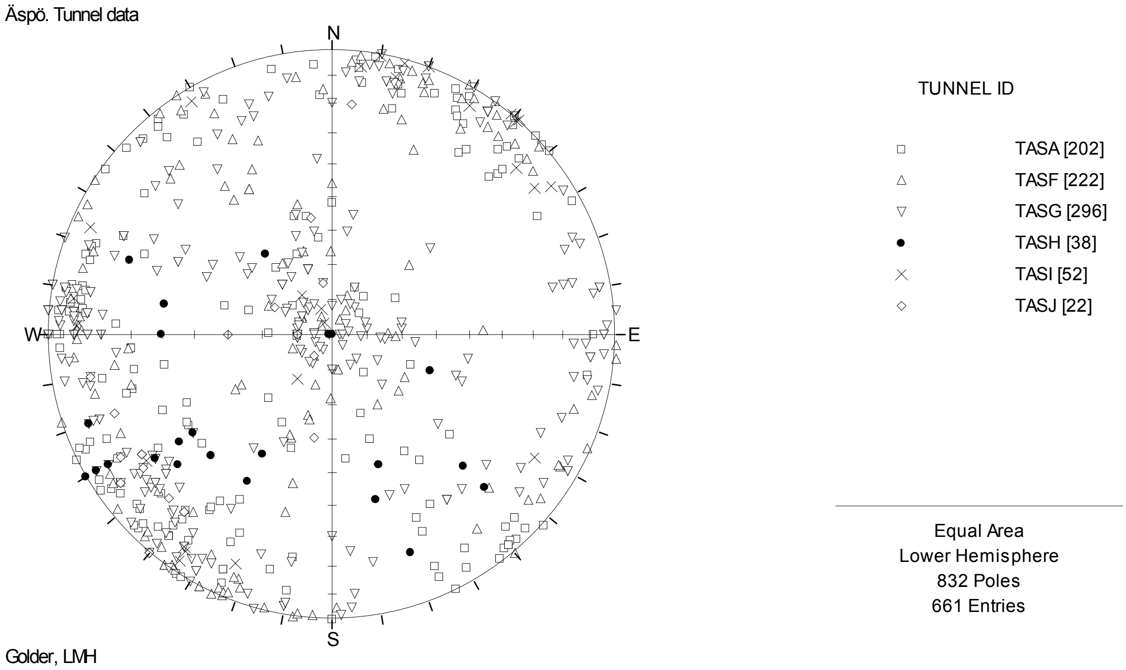


Figure 10 *Plot of Borehole metres with respect to trend.*

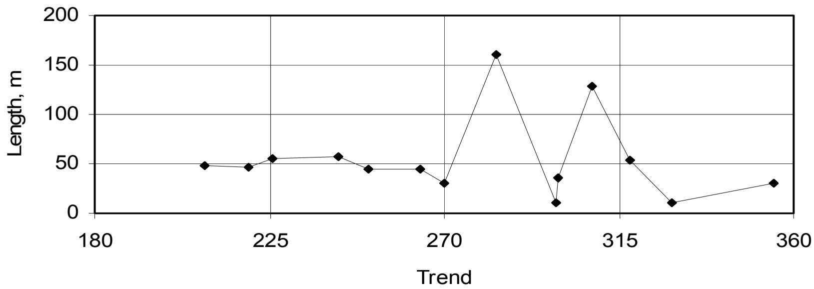


Figure 11 *Plot of accumulated borehole length with respect to plunge.*

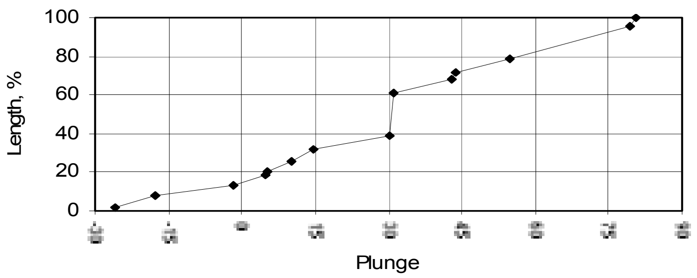


Figure 12 *Stereonet pole plot of joints in 50 m model. Boreholes KA2599G01 and KF 0093A01.*

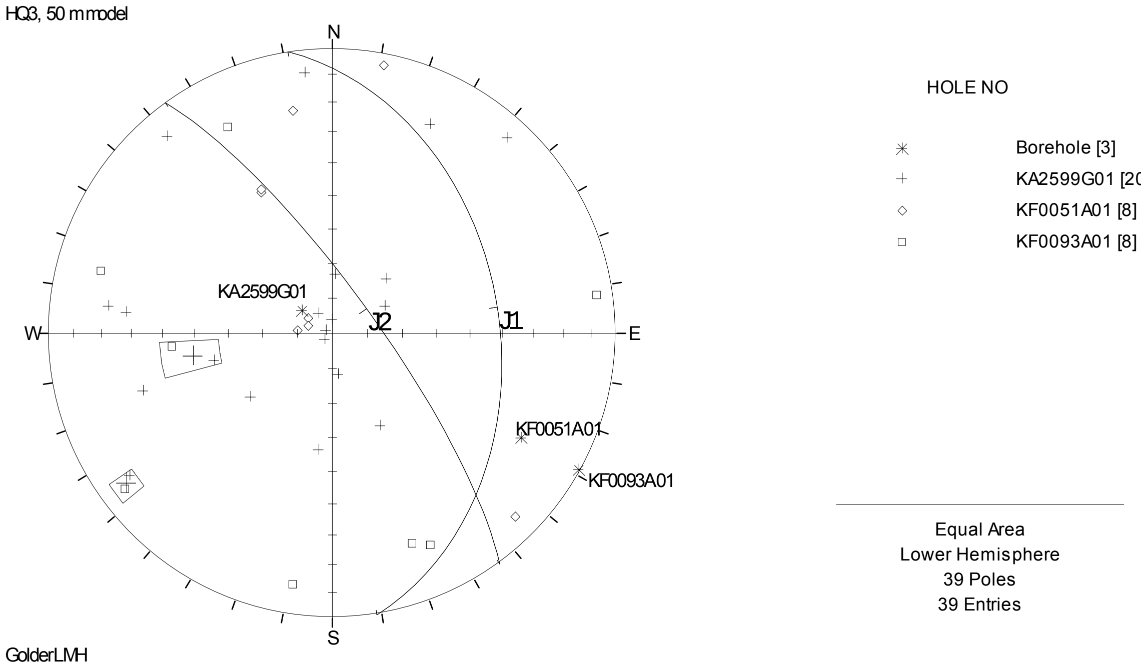
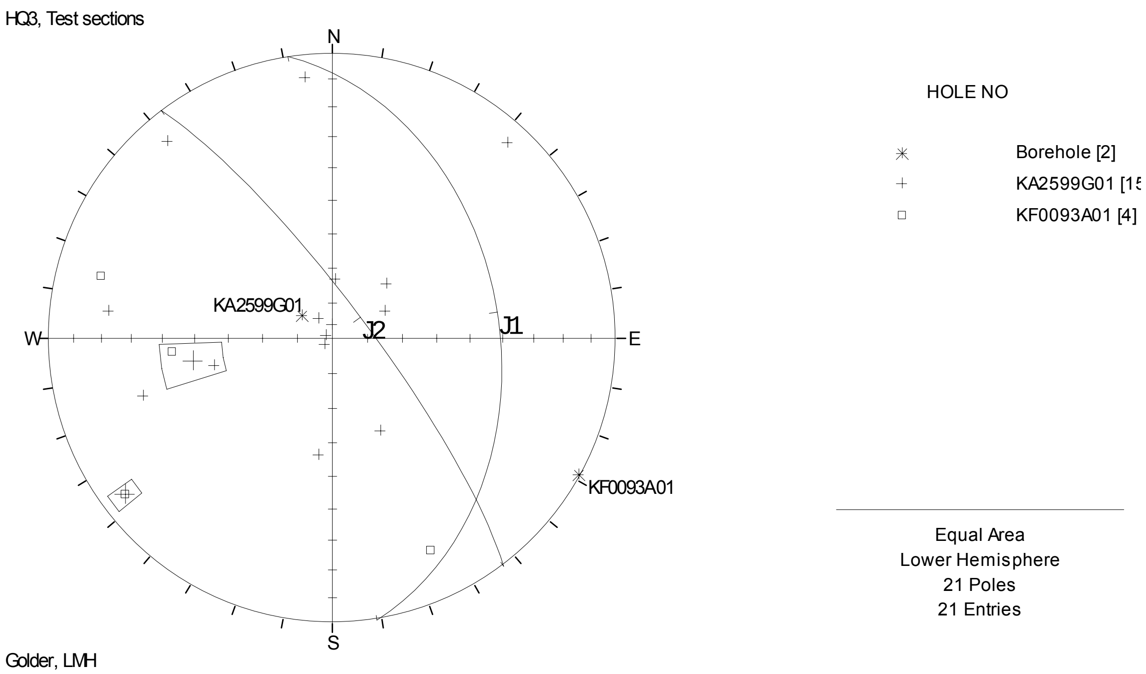


Figure 13 *Stereonet pole plot of joints in rock stress test sections, in boreholes KA2599G01 and KF 0093A01.*



Appendix I Terzaghi weigthing of contour plot

The Terzaghi Weighting option, available in the View menu and the View toolbar, can be applied to Contour and Rosette plots, to account for the sampling bias introduced by orientation data collection along Traverses.

When orientation measurements are made, a bias is introduced in favour of those features which are perpendicular to the direction of surveying. To illustrate this concept, three joints of identical spacing along a scanline are shown below.

Measurements along the scanline record many more joints in Set A than in Set C, which will bias the density contour plot heavily in favour of Set A. To compensate for this bias, a geometrical weighting factor is calculated and applied to each feature measured. This weighting, W, can be applied to contour and rosette plots in DIPS, and is also used in the weighted mean vector calculations. The bias correction should only be used for planar features, and will not account properly for measurement bias in linear features such as acicular crystal fabric.

The geometric weighting factor, W, is calculated as follows:

a = minimum angle between plane and traverse

D’ = apparent spacing along traverse

D = D’ sina = D’ (1/W) = true spacing of discontinuity set

R’ = 1/D = 1/D’ sina = D’ coseca = true density of joint populationW = (1) coseca = weighting applied to individual pole before density calculation

Since the weighting function tends to infinity as approaches zero, a maximum limit for this weighting must be set to prevent unreasonable results. This maximum limit corresponds to a minimum angle, which can be between 0.1° and 89.9°. However, the recommended range is limited to 5° to 25°, and the default is set to 15°. The user can change this limit with the Bias Angle option.

The effect of applying the Terzaghi weighting to some data distributions can be quite severe. If you use weighted data plots for design or interpretation, be sure you understand the weighting procedure.

The results of applying the weighting procedure to a sample data file are shown in the following figure. In this case, there is a very important subnormal group of joints, which is masked by abundant structural data collected on horizontal scanlines. In this case, the heavy bias introduced by the horizontal data can be removed by weighting the data.

Illustration of Terzaghi weighting – unweighted (left) and weighted (right) contours of sample data.

Note that the Terzaghi Weighting option is only enabled if you have defined Traverses in your DIPS file (ie. if at least one traverse has been defined in the Traverse Information dialog). If no traverses exist, then the Terzaghi Weighting option is not applicable and will not be available.