P-03-86

Oskarshamn site investigation

Visualization of structural geological data covering the Simpevarp peninsula, Ävrö and Hålö

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September 2003

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Summary

The aim of the current project is a 3D visualization of archive material presented in the report; *Compilation of structural geological data covering the Simpevarp peninsula, Hålö and Ävrö* (SKB report P-03-07). The work has been based on information contained in existing reports and documents of diverse origin: SKB published and unpublished reports; site investigation records; construction and 'as built' drawings from the major infrastructure projects on the peninsula.

The earlier report and GIS database constitute a simplistic 2 dimensional structural geological model covering the Simpevarp peninsula, Ävrö and Hålö. The database includes strike, dip and width information. The current project involves the next logical step, to apply this 3D geometrical information to the existing 2D lineament and structure traces, to provide a 3D visualization of existing interpretations of the structural geology at the peninsula scale and provide background information for the ongoing site investigations and more detailed local site scale models.

This written report presents the working method used to fix the structures' positions in 3D but only presents a partial and incomplete set of results due to the project being curtailed. Available results include 48 visualized structures, of which 39 have documented coordinate information.

Contents

1 Introduction

A previous report "Compilation of Structural Geological data covering the Simpevarp peninsula, Ävrö and Hålö" (SKB report P-03-07) provided the input data to the current project.

In summary it can be said that the previous report and GIS database (P-03-07) constitute a simplistic two-dimensional structural geological model covering the Simpevarp peninsula, Ävrö and Hålö. Although the initial framework has been laid down by the recent compilation study it is still in a basic format. The 2D geometry of the lineaments and structural features are all presented in the RT90 coordinate system with traceability to the source report material. In addition, all available information from the references, characterising the lineament and structures, including their strike dip and width, are compiled in a data table.

The current report presents the next logical step, to apply this 3D geometrical information to the existing 2D lineament and structure traces, to provide a 3D visualization of existing interpretations of the structural geology at the peninsula scale and provide background information for the ongoing site investigations and more detailed local site scale models.

The work has been carried out using SKB's visualization tool RVS. The Rock Visualization System (RVS) has been developed by SKB for visualizing geological and engineering data and constructing structural geological models to assist with the siting and design of a deep repository.

This written report presents the working method used to fix the structures' positions in 3D and the results of a limited amount of visualization work. Available results include 48 visualized structures, of which 39 have documented coordinate information. An explanation of the naming system applied to the structures is presented in Appendix A. Selected views taken from the visualization work are presented in Appendix B with coordinate and orientation details for the structures included in Appendix C.

1.1 Project area

The project area is shown below and encompasses the Simpevarp peninsula and the islands of Hålö and Ävrö.

Figure 1-1 includes the major infrastructure, relevant to the current project, present in the project area. The footprint of surface structures is shown in grey and the underground excavations shown in green.

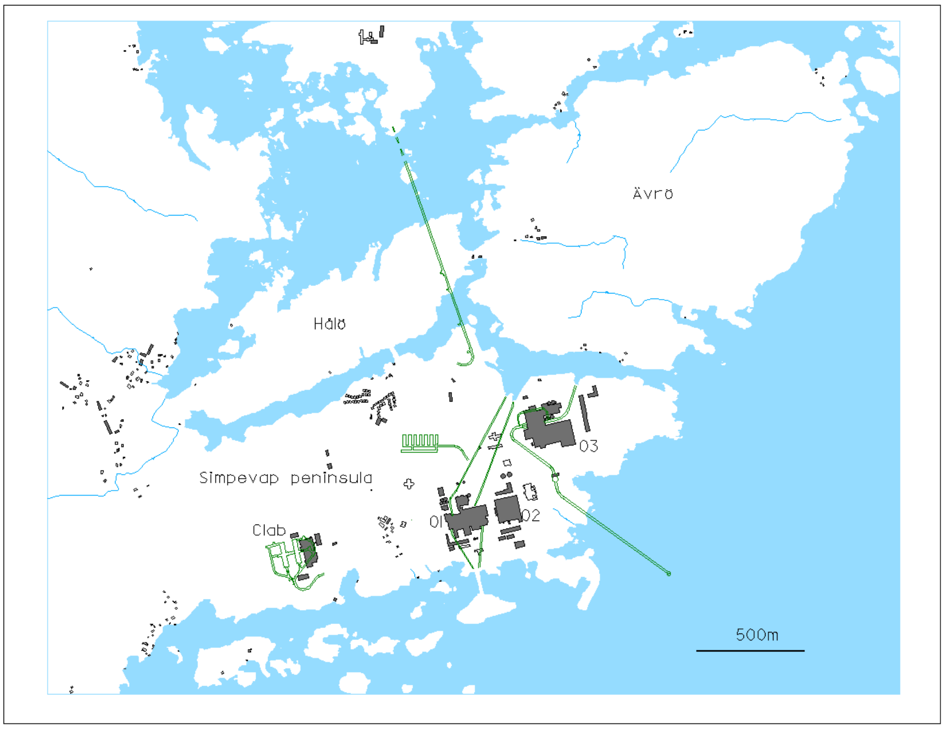

Figure 1-1. *The Project Area: Simpevarp peninsula, Ävrö and Hålö, showing the major infrastructure (underground works shown in green).*

The current project has relied on the results of geological mapping of the various excavations, to supply primary information on the character of tectonic structures present in the project area and give indications of local orientation.

1.2 Aim

This report contains no new data and no new interpretations of existing data. The aim of the current report is to provide a systematic 3D visualization of previously compiled structural geological information that is relevant to the project area.

2 Data selection

2.1 Selection of structures for visualisation

The earlier compilation work focused on an inventory of old data from the Simpevarp peninsula associated with the investigation and construction of:

- Units O1 and O2.
- Unit O3.
- Clab 1.
- Clab 2.

(see report P-03-07 for details)

Where suitable orientation information is available, structures with a mapped width of greater than 0.5 m, encountered in underground excavations, have been visualized in 3D. This is done by combining the 2 and 3D data sources and generating discs of suitable size. A total of 48 structures have been visualized. The local geometries and coordinates of these structures are included in Appendix C.

2.2 Limitations and use of the compiled data format

One disadvantage with digitising the interpreted structures and transferring their geometry to another working environment is that they are no longer seen in the context of the data or time that they were produced. Interpreted structures from very different data sources and levels of certainty appear to have equal significance when viewed in a compilation drawing or on the computer screen. For this reason the digitised lines, areas and points representing the interpreted structures should not be used in isolation. The selected original source drawings are available for reference in digital format and have been included in the data delivery associated with the earlier compilation report (P-03-07).

3 Working method

The visualization work was carried out using SKB's in-house developed software, RVS (Rock Visualization System), which functions as an application working within the Microstaion V8 environment.

Although the visualization process should be generally straightforward there are a number of potential pitfalls:

- **Fixing observation depths**

  As previously stated, the compilation project resulted in a simplistic two-dimensional geometry – the network of lineaments and structures in GIS. However, there is a mixed origin to this data, some lines represent topographic and geophysical lineaments, that is to say surface data, whereas some lines originate from the mapping of underground facilities i.e. they represent the position of those features at a specific depth. Although this difference is relatively small and is considered irrelevant for the regional Version 0 model, it becomes of increasing relevance for the more local scale work. The difference between surface and underground origins to the data is identified in the compilation study and this information is used to identify a suitable Z value (depth) when the structures are placed in 3D.

  Only directly mapped structures in excavations have been processed in the current project.

- **Differentiating between local tunnel observations and more geographically extensive surface lineaments**

  In practice such modelling can be carried out in RVS by modelling the 'tunnel' fracture zones as oriented discs of a suitable diameter and, where orientation information is available, modelling the lineament traces as dipping undulating surfaces with an applied thickness. At a later date these tunnel observations can be assigned as 'measurement points' for existing zones or possibly used to define more extensive geometries of new zones. The current report only includes information based on underground mapping work. The visualization of existing interpretations based on surface evidence such as topographic lineations and mapping has not been included in this report.

- **Maintaining Traceabilty**

  The traceability that was established in the compilation project was continued in the current work by giving the modelled objects the same ID numbers that were assigned during the compilation phase. In this way any of the individual visualized objects can be traced back to the original source data.

- **No new interpretation**

  The intention of the current visualization work is to produce a 3D representation of the interpretations available to date. It presents existing 'historical' interpretations made by numerous geologists during the excavation of the major infrastructure projects on the peninsula. The aim being to provide background information to assist future modelling work by highlighting potential inconsistencies and incompatibilities in existing interpretations as well as suggesting potentially new links between structures. This initial phase is 'non interpretive' and only highlights locations which require further work.

- **The working environment and distribution of information**

  The modelling work is carried in the Microstation and RVS environment with continual reference to the original source drawings and GIS database. This required the conversion of the GIS geometry files into Microstation design file format.

  The resulting 3D geometries produced in RVS can be exported directly in Microstation and AutoCad formats for viewing by any non-specialist user with a free Viewer program, Bentley Viewer. This allows viewing of the visualised geometry and particular zone geometries in 3D with the ability to zoom in and out and rotate the model etc.

Appendix A

Data Inventory based on SKB reference list: Format and Coding

Numbering format used:

ID

Example 1	ID7_3_005	***(Linked to GIS)***

ID7	Identification Number taken from SKB's original reference list. The data referred to was sometimes a specific report, sometimes a group of reports and sometimes a general subject area such as O3 data.
_3	This number refers to a figure selected from the report(s). In this case the third in a sequence. The figure has been scanned and georeferenced.
_005	This number refers to a particular structure, e.g. a lineament in the figure. The structure, represented in the figure by an area, line or point has been digitised and included in the GIS database linked to the table.

Appendix B

General views taken from initial visualization work

Visualization of archive data

- Only fracture zones with a minimum thickness of 0.5 m have been visualized. Fracture zones identified in the Äspö access tunnel have been visualized as discs or cylinders. Fractures identified in O1, O2 , O3 and Clab 1 and 2 excavations have been visualized as lenses. All the visualized fracture zones have been given an arbitrary diameter of 200 m for clarity.

- All the discs have been modelled with their true thickness taken from the archive documentation, however, this is not clearly visible in the figures included here due to the scale used for presentation. Zone thickness values along with dip and strike details are presented in Appendix C.

- Purple or mauve discs represent zones that were dry in the excavations or for which no leakage information was presented.

- Light blue discs represent zones that were recorded as 'dripping' in the excavations.

- Dark blue discs represent zones that had a recorded 'flow'.

- The orange brown lens (ID8_11_011) represents a marked 'disturbed section' in the O3 intake tunnel. The orientation shown has no significance. It is simply perpendicular to the tunnel alignment. However, it is reported as corresponding to a 20–40m wide depression on the surface. The "strike" of this depression should be investigated.

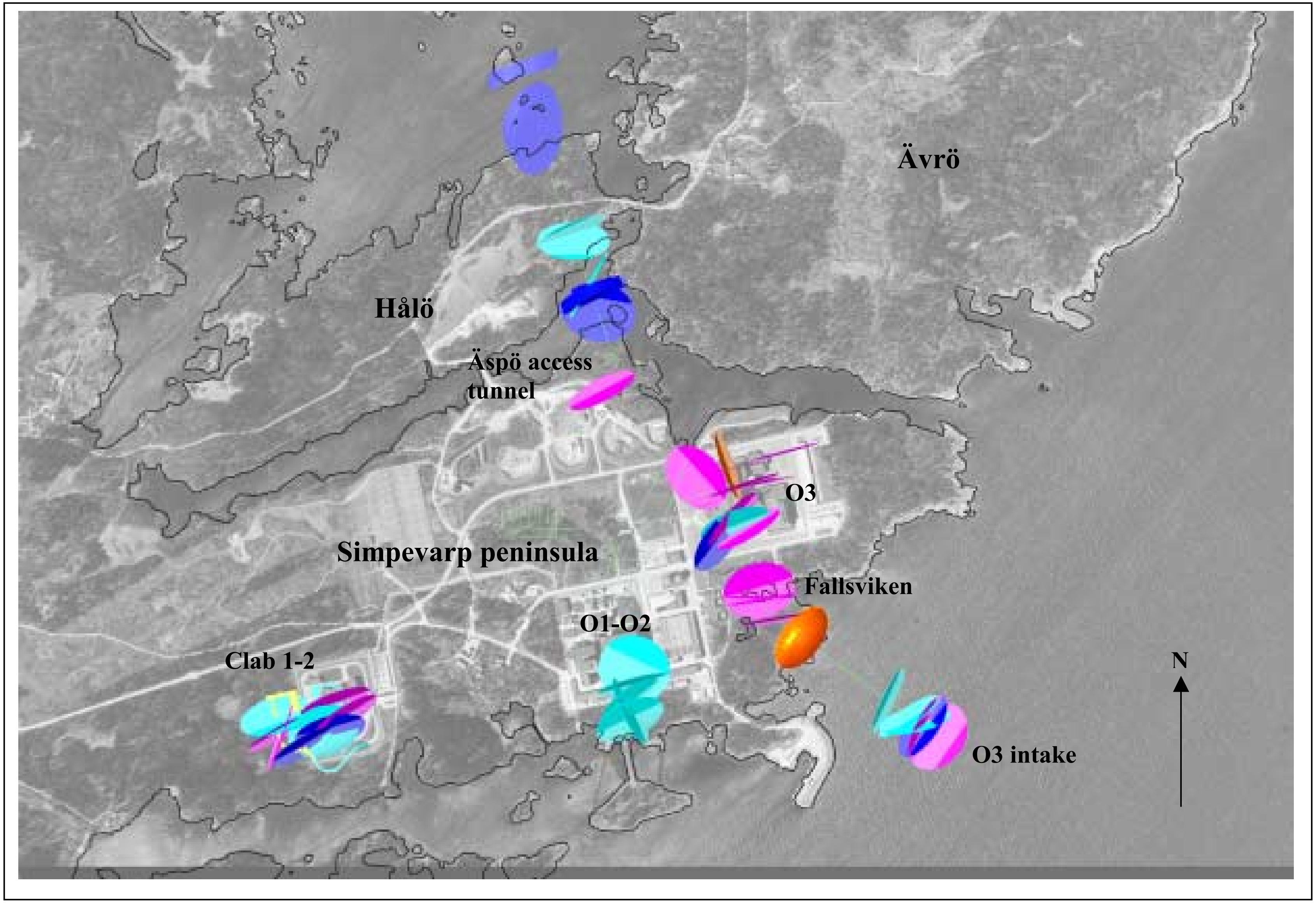

Figure B-1. *Top view: location plan of project area with visualized structures including a semi transparent, horizontal surface, set at an elevation of 0 m and orthophoto – gives an indication of the approximate outcropping positions of the various zones.*

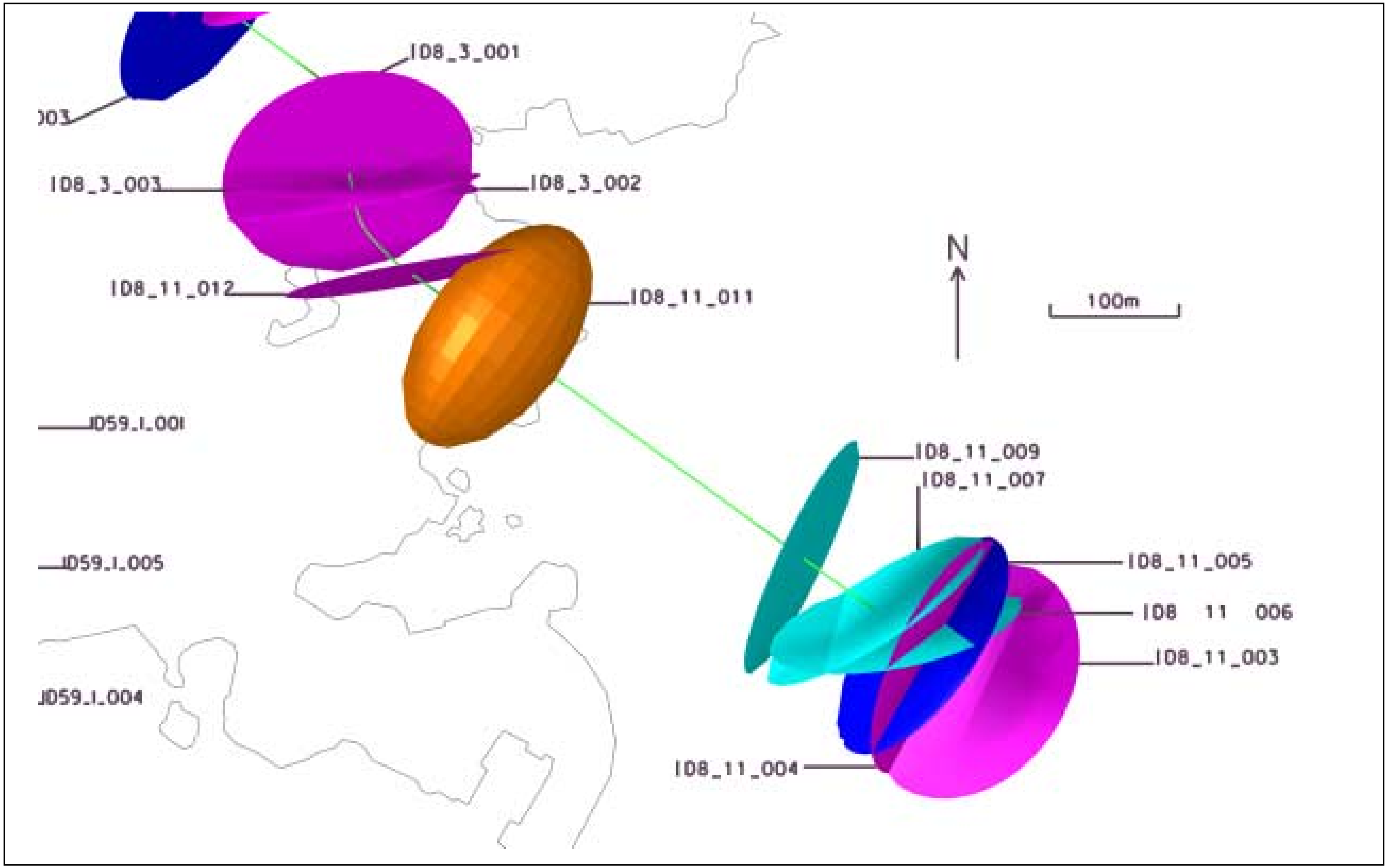

Figure B-2. *O3 Intake tunnel part one and "Fallsviken zone". Figure showing identification numbers of visualized fracture zones, see Appendix C for orientation details. See report P-03-07 for further zone characterisation details.*

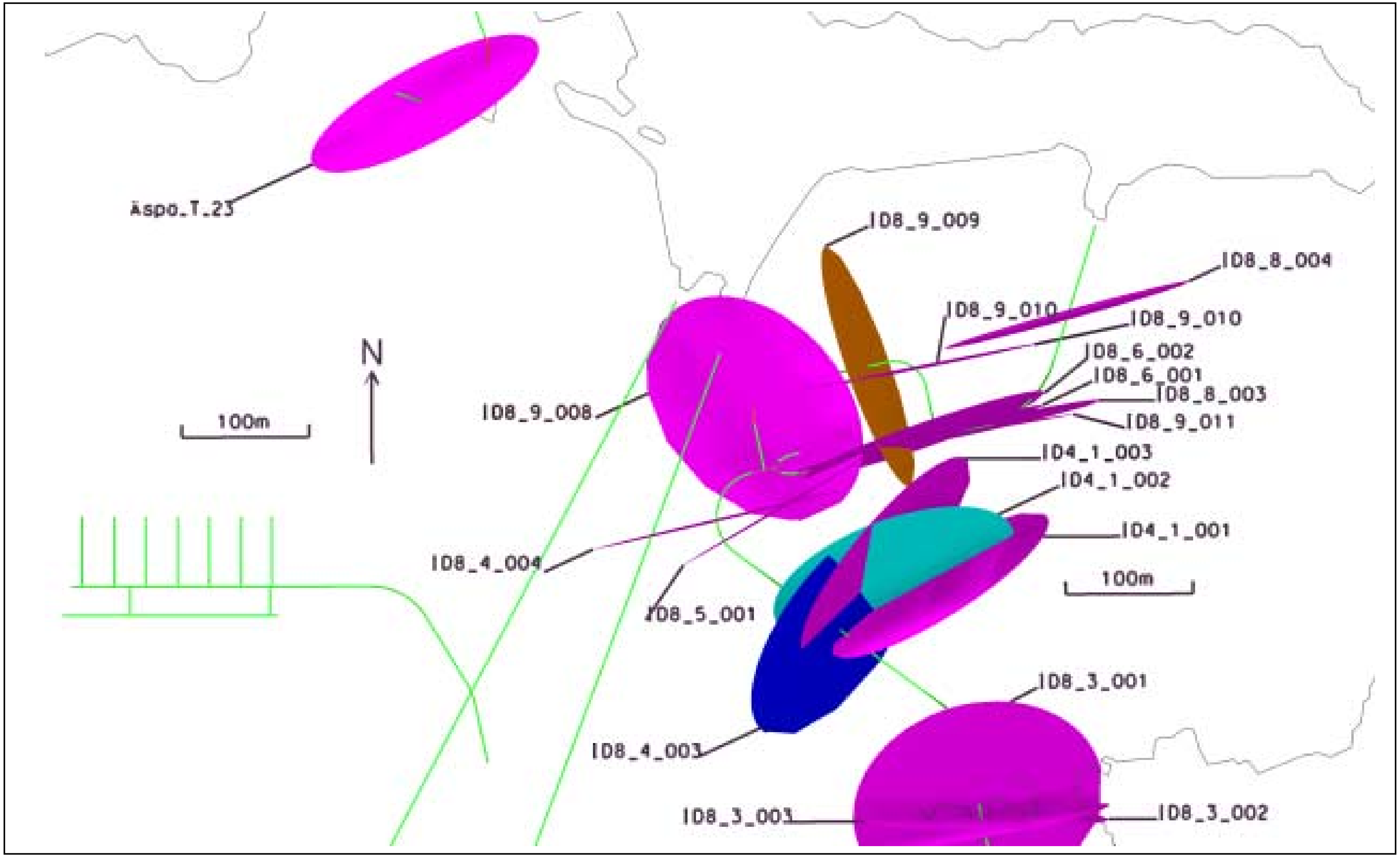

Figure B-3. *O3 Intake tunnel part one continued to tailrace. Figure showing identification numbers of visualized fracture zones, see Appendix C for orientation details. See report P-03-07 for further zone characterisation details.*

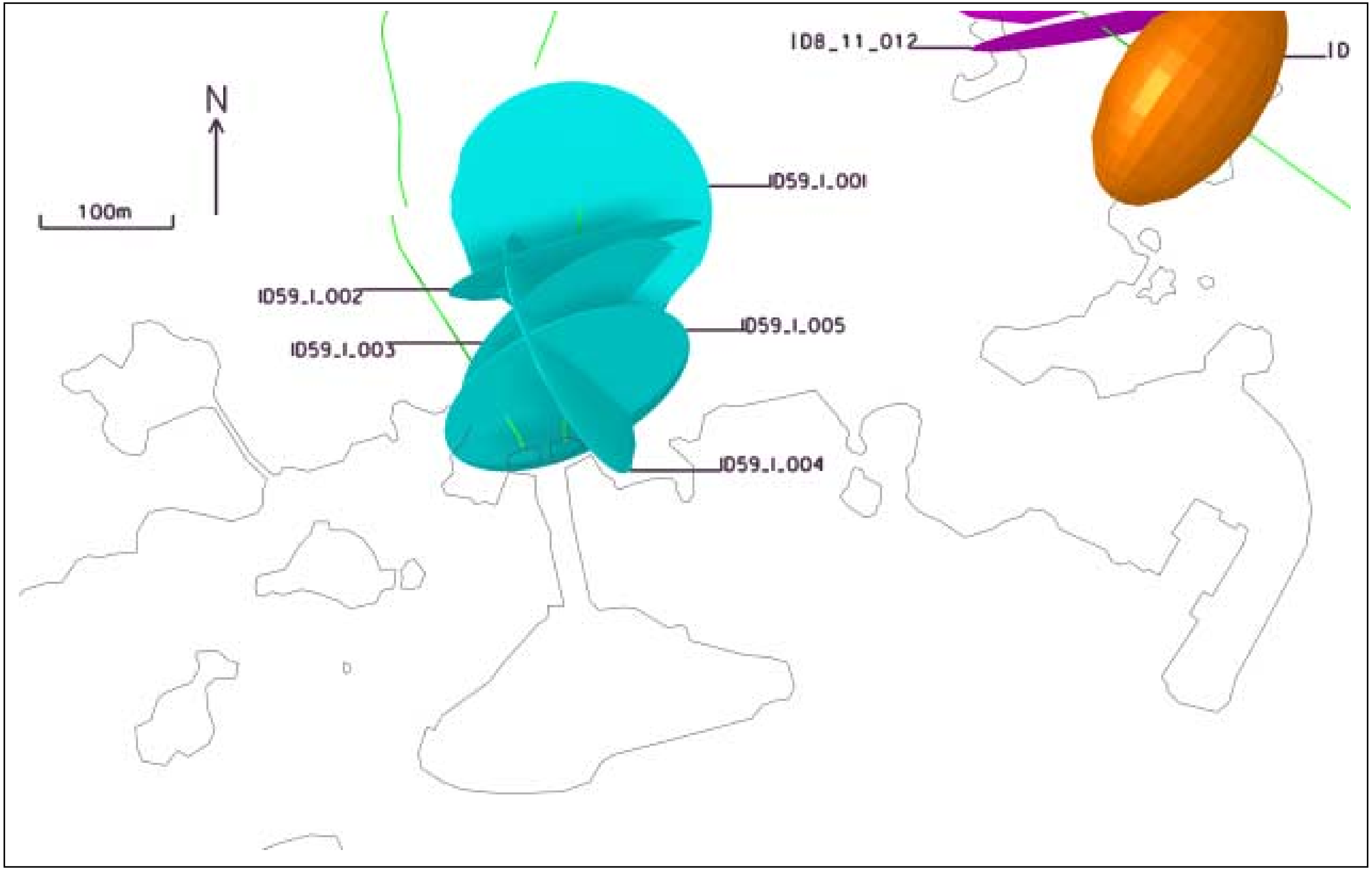

Figure B-4. *O1 and 2 Intake tunnels (INCOMPLETE VISUALIZATION). Figure showing identification numbers of visualized fracture zones, see Appendix D for orientation details. See report P-03-07 for further zone characterisation details.*

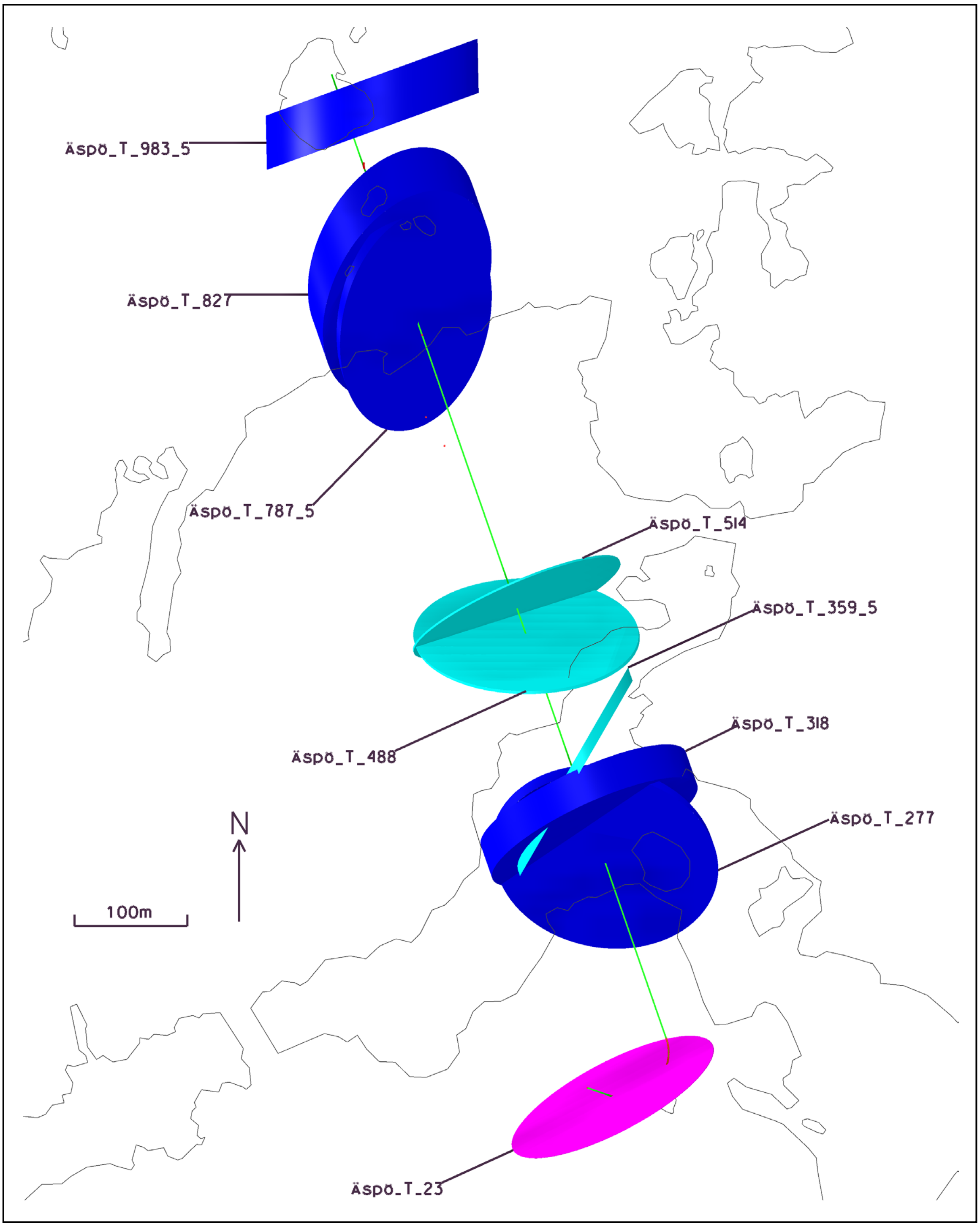

Figure B-5. *Äspö access tunnel. Figure showing identification numbers of visualized fracture zones, see Appendix C for orientation details.*

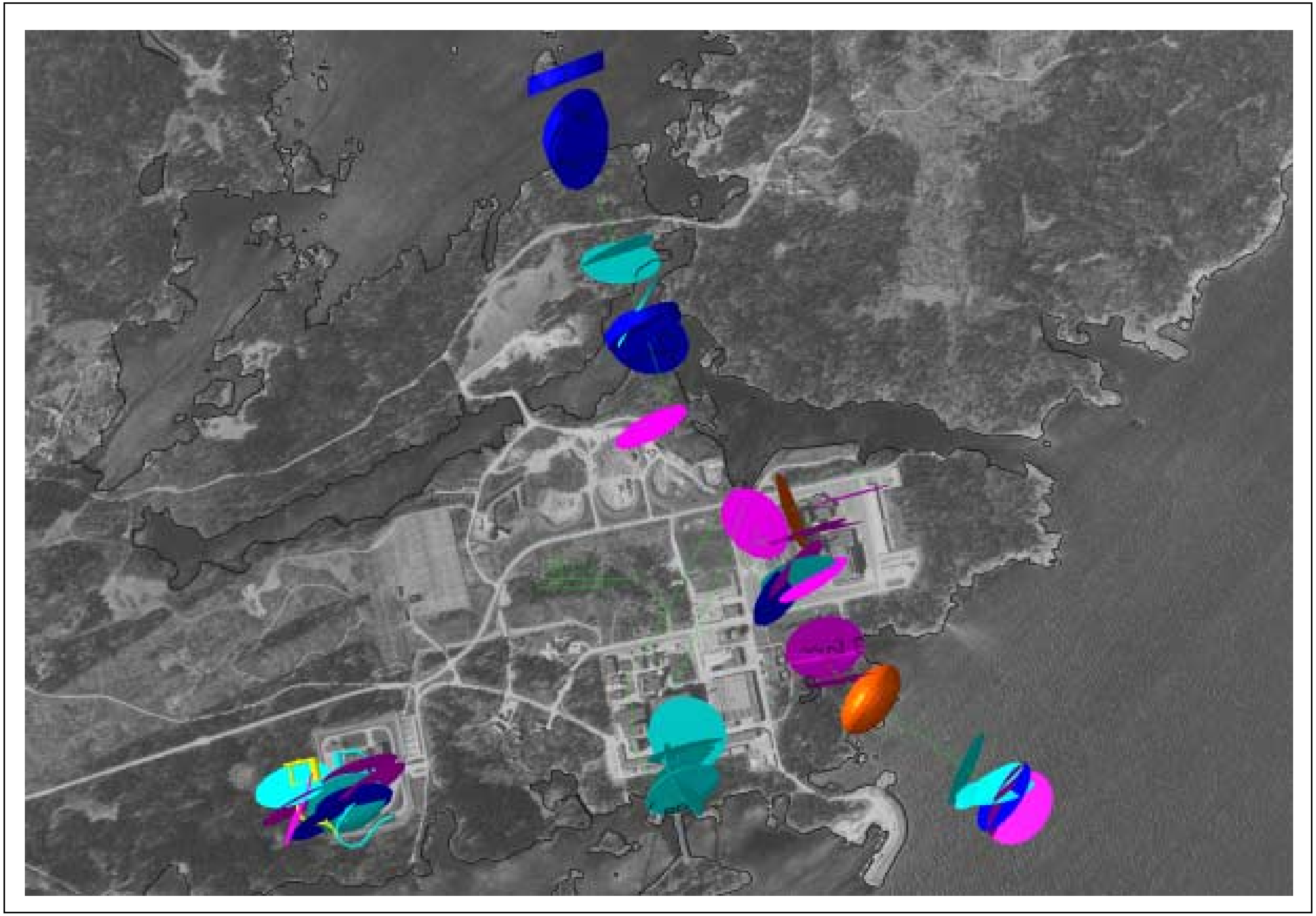

Figure B-6. *Top View, including orthophoto.*

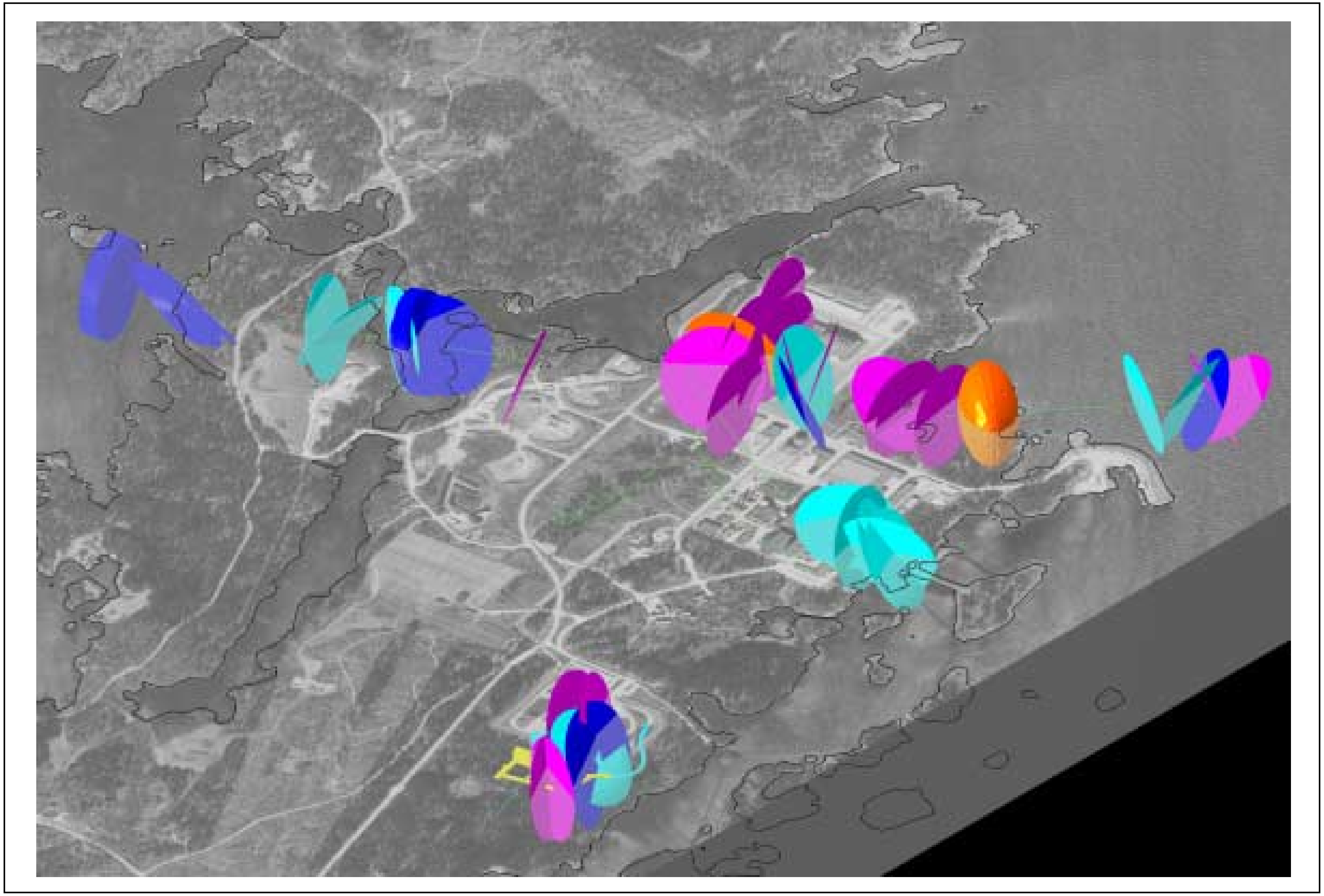

Figure B-7. *Isometric view, looking NE: including a semi transparent, horizontal surface, set at an elevation of 0 m and orthophoto – gives an indication of the approximate outcropping positions.*

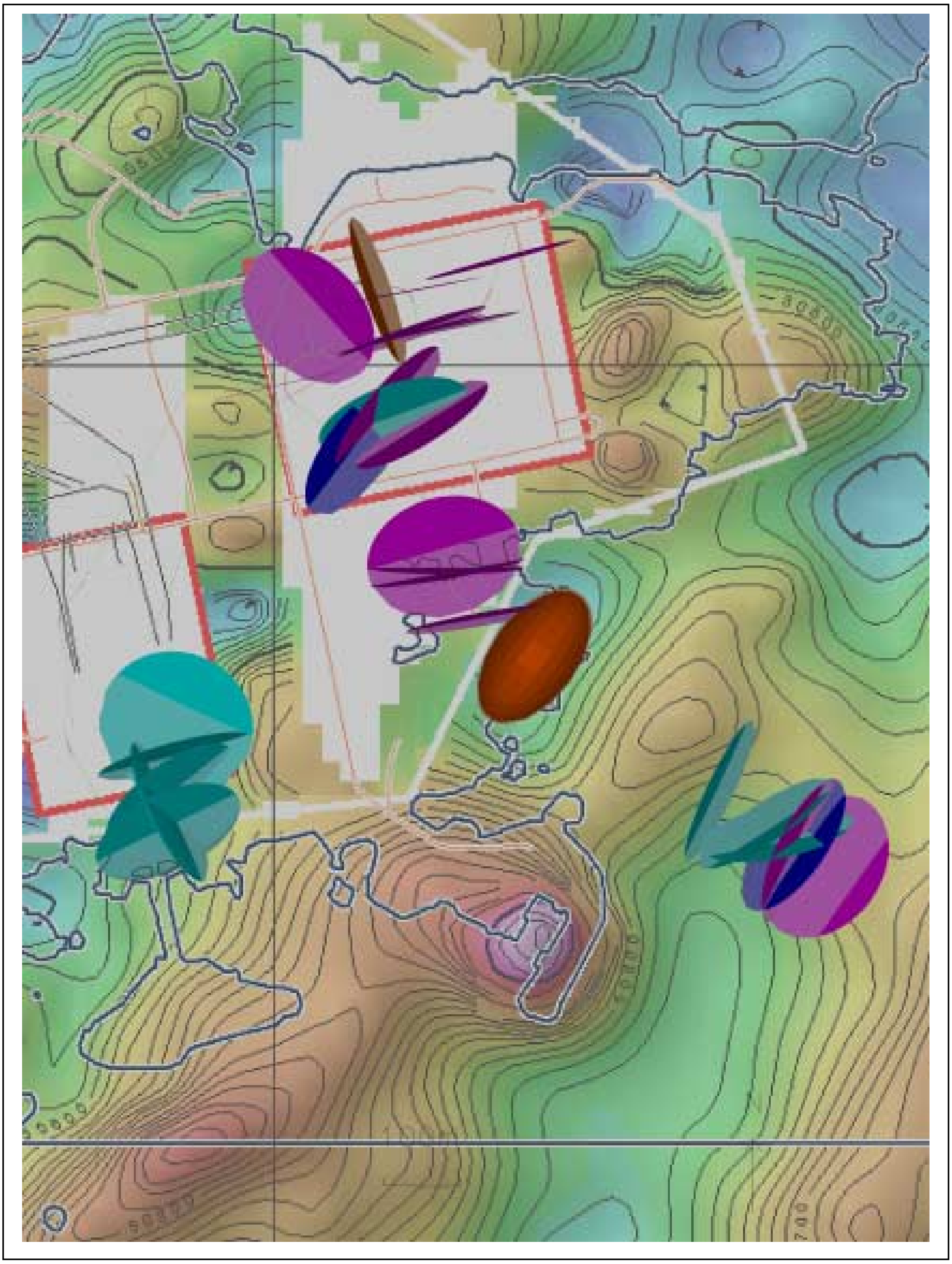

Figure B-8. *Top view: including a semi transparent, horizontal surface, set at an elevation of 0 m and results of magnetic aerial survey.*

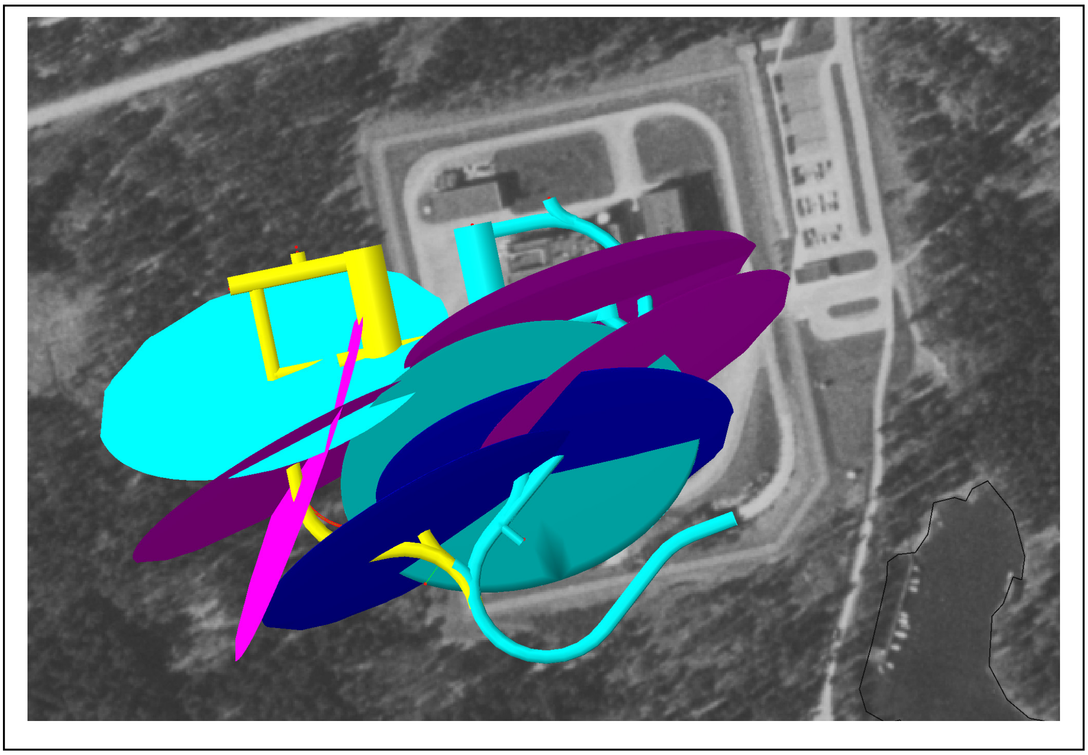

Figure B-9. *Clab 1 and 2, top view including orthophoto (Note:INCOMPLETE VISUALIZATION).*

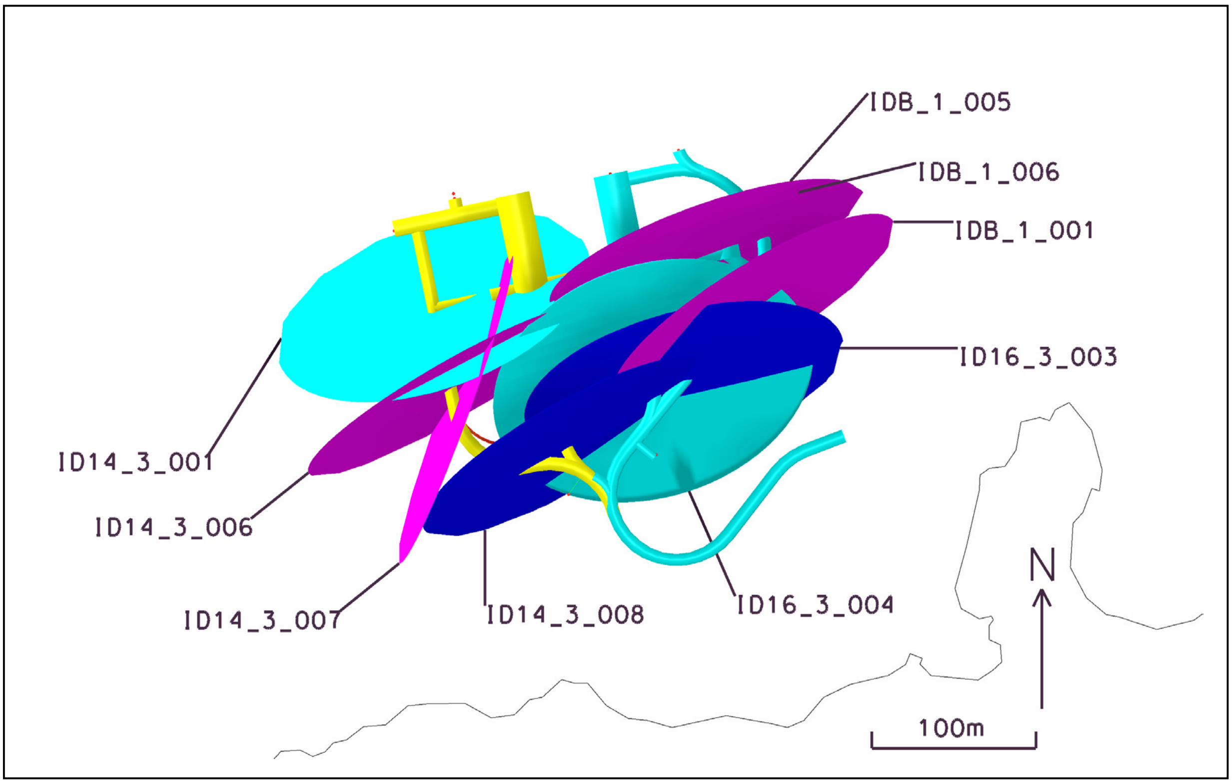

Figure B-10. *Clab 1 and 2, top view, identification numbers of visualized fracture zones, see Appendix C for orientation details. See report P-03-07 for further zone characterisation details.*

Appendix C

Orientation of visualized structures

Orientation of visualized structures

O3 Intake tunnel part one **(RT90 coordinate system)**

ID	Local strike	Local dip	Width (m)	X (m)	Y (m)	Z (m)	Character (additional characterisation information available in P-03-07)
ID8_11_003	215	40W	2-3	1552703.1	6365358.3	-40.9	Highly fractured, partly crushed zone. Clay and chlorite filled fractures.
ID8_11_004	025	70E	1-2	1552678.8	6365376.0	-39.8	Crushed zone in fine-grained granite. Chlorite-calcite filled fractures.
ID8_11_005	215	65N	ca.10	1552665.8	6365385.5	-39.4	Highly fractured fine-grained granite. Partly crushed and altered.
ID8_11_006	260	70N	0.5	1552644.2	6365401.2	-38.2	"Sköl" (gouge filled fracture). Chlorite and minor clay.
ID8_11_007	235	75N	1	1552628.8	6365412.4	-37.5	"Sköl" (gouge filled fracture). Chlorite and minor clay.
ID8_11_009	025	80S	ca.5	1552572.0	6365453.8	-34.9	Highly fractured fine-grained granite. Limonite.
ID8_11_011	*		ca.100	1552334.6	6365626.7	-24.1	Complex deformation zone with increased fracturing and a great number of dykes of fine-grained granite, "skölar" and fractures with chlorite and clay (dip 65-80S). Partly altered rock *Reported as corresponding to a 20-40m wide depression on the surface- check "strike"
ID8_11_012	080	85S	ca.1m	1552268.4	6365675.0	-21.0	Partly crushed fine-grained granite in contact with calcite-chlorite filled "sköl"

O3 Intake tunnel part one- "The Fallsviken zone"

ID	Local strike	Local dip	Width (m)	X	Y	Z	Character
ID8_3_001	075	40S	ca.2	1552219.1	6365755.0	-9.9	Fracture zone, partly crushed and altered.
ID8_3_002	270	85N	1-2	1552221.9	6365741.6	-11.8	Fracture zone
ID8_3_003	260	85N	1-2	1552223.2	6365735.2	-12.6	Fracture zone

O3 Intake tunnel part one continued-

ID8_5_001	060	90		1552074.9	6365992.3	-4.5	"Turbinskölen" (same as ID 8_8_003)
ID8_6_001	075	90-85S	0.1-0.5	1552174.7	6366040.0	-9.0	Splay of "Turbinskölen"
ID8_6_002	070	90-80S	0.1-0.5	1552178.6	6366043.6	-9.0	Splay of "Turbinskölen"

O3 Intake tunnel part two

ID8_4_003	035	65S	5-7	1552108.9	6365892.6	-19.9	Highly fractured zone, partly crushed and clay altered
ID8_4_004	075	90	0.5-1	1552014.7	6365977.4	-19.3	“Sköl”. Chlorite. ("Turbinskölen")

O3 Emergency cold water tunnel

ID	Local strike	Local dip	Width (m)	X	Y	Z	Character
ID8_9_008	140	45S	1-1.5	1552044.8	6366064.8	-19.5	"Sköl" with chlorite in an altered dyke of fine-grained granite.
ID8_9_009	340	80E	0.1-0.5	1552134.1	6366097.5	-20.5	"Sköl" with calcite and chlorite. (minor shear zone/fine-grained granite, modelled since it coincides with ID63_1_010 on the surface)
ID8_9_010	080	90	1.5-2	1552170.7	6366095.8	-20.8	"Sköl" with chlorite in altered dyke of fine-grained granite.
ID8_9_011	080	90		1552197.9	6366043.6	-1.8	ID8_9_011 = ID8_8_003, "Turbinskölen"

O3 Tailrace tunnel

ID8_8_003	080	90-85S	0.5-1	1552219.2	6366049.2	-18.1	"Turbinskölen" with chlorite and clay.
ID8_8_004	075	90	ca.10	1552291.3	6366137.1	-17.3	Dyke with fine-grained granite, highly fractured and partly crushed.

O3 Reactor building

ID	Local strike	Local dip	Width (m)	X	Y	Z	Character
ID4_1_001	238	75N	0.1-0.5	1552189.4	6365925.5	-5.0	Fracture zone (1m represents increased fracturing width).
ID4_1_002	070	65S	0.1-0.5	1552153.8	6365934.0	-5.0	"Sköl" with chlorite, calcite and clay. (1-5m represents increased fracturing width).
ID4_1_003	040	75E	0.5-1.5	1552147.7	6365947.5	-5.0	Shearzone with chlorite, calcite and dykes of fine-grained granite.

O1-O2 Intake tunnel

ID59_1_001	115	20S	ca.1	1551875.8	6365538.7	-10.5	Fracture zone. Chlorite and clay
ID59_1_002	075	80S	ca. 5	1551872.8	6365499.0	-14.9	Fracture zone. Chlorite and clay -oxidised.
ID59_1_003	050	65E	2-3	1551868.7	6365445.6	-12.4	Complex shear zone. Partly crushed with chlorite, calcite and clay.
ID59_1_004	335	75N	10-15	1551867.4	6365428.4	-11.7	"Sköl" . Oxidised with clay.
ID59_1_005	065	60S	ca.1	1551865.4	6365401.9	-10.4	Brecciated zone with chlorite, calcite and clay.

CLAB

ID	Local strike	Local dip	Width (m)	X	Y	Z	Character
ID14_3_001	250	60N	ca.1	1550893.6	6365414.6	-41.0	Shearzone with mylonite, chlorite, calcite and clay.
ID14_3_006	060	80S	0.1-0.5	1550904.2	6365363.5	-35.7	Shearzone.
ID14_3_007	200	85N	0.1-0.5	1550907.1	6365352.5	-34.4	Shearzone.
ID14_3_008	060	75S	4-5	1550963.4	6365323.3	-26.6	Shearzone with chlorite, calcite, clay and mylonite.
ID16_3_003	075	65S	5	1551046.3	6365369.5	-30.0	Same as ID14_3_008.
ID16_3_004	070	45S	0.1-0.5	1551027.6	6365369.6	-29.5	"Sköl" with chlorite.
IDB_1_001	060	75S	2	1551089.0	6365413.5	-7.0	Highly fractured, partly crushed rock with chlorite and clay.
IDB_1_005	070	75S	0.5-1	1551058.9	6365450.2	-7.0	"Sköl" with clay.
IDB_1_006	070	80S	0.5-1	1551061.5	6365450.0	-7.0	"Sköl" with clay, part of a complex zone.

Äspö access tunnel: Ref: SKB PR 25-95-20, Supplementary Investigations of Fracture Zones in Äspö Tunnel; Appendix 3 Fracture Zone Catalogue compiled by Kristian Annertz 1995.Numbers in the ID column refer to tunnel chainage in metres.

ID	Local strike	Local dip	Width (m)	X	Y	Z	Character
Äspö_T23	242	72N	0.5	-	-	-	Fracture zone
Äspö_T277	100	40S	8.5	-	-	-	Fracture zone
Äspö_T318	065	75S	31	-	-	-	Fracture zone
Äspö_T359_5	210	90	12.5	-	-	-	Fracture zone
Äspö_T488	270	60N	3	-	-	-	Fracture zone
Äspö_T514	066	78S	2	-	-	-	Fracture zone ("redox zone", PR25-95-20)
Äspö_T787_5	015	50E	10	-	-	-	Fracture zone ("EW7", PR25-95-20)
Äspö_T827	030	50S	41	-	-	-	Fracture zone ("NE4", PR25-95-20)
Äspö_T983_5	250	90	48.5	-	-	-	Fracture zone ("NE3", PR25-95-20)