SKB

TECHNICAL REPORT 91-20

Äspö Hard Rock Laboratory. Overview of the investigations, 1986-1990

R Stanfors, M Erlström, I Markström

June 1991

SVENSK KÄRNBRÄNSLEHANTERING AB
SWEDISH NUCLEAR FUEL AND WASTE MANAGEMENT CO
BOX 5864 S-102 48 STOCKHOLM
TEL 08-665 28 00 TELEX 13108 SKB S
TELEFAX 08-661 57 19

ÄSPÖ HARD ROCK LABORATORY.
OVERVIEW OF THE INVESTIGATIONS 1986-1990

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ÄSPÖ HARD ROCK LABORATORY

OVERVIEW OF THE INVESTIGATIONS 1986-1990

Roy Stanfors
Mikael Erlström
Ingemar Markström

1991-04-25

ABSTRACT

In order to prepare for the siting and licensing of a spent fuel repository SKB has decided to construct a new underground research laboratory.

The pre-investigations for the Äspö Hard Rock Laboratory started in late 1986.

This report gives a comprehensive compilation of the different investigations performed during the pre-investigation phase (1986-1990). The information is mainly compiled in CAD-generated maps and illustrations in which the reader can gather information concerning the scope of work as well as references to more detailed reports for further study.

TABLE OF CONTENTS

INTRODUCTORY COMMENT

This report is No I, of four summarizing the pre-investigation phase of the Äspö Hard Rock laboratory.

The reports are:

I — Stanfors R, Erlström M, Markström I.
Äspö Hard Rock Laboratory
Overview of the investigations 1986-1990.
SKB TR 91-20

II — Almén K- E, Zellman O.
Äspö Hard Rock Laboratory
Field investigation methodology and instruments used in the pre-investigation phase, 1986-1990.
SKB TR 91-21

III — Wikberg P, Gustafson G, Rhén I, Stanfors R.
Äspö Hard Rock Laboratory
Evaluation and conceptual modelling based on the pre-invegations 1986-1990.
SKB TR 91-22

IV — Gustafson G, Liedholm M, Rhén I, Stanfors R, Wikberg P.
Äspö Hard Rock Laboratory
Predictions prior to excavation and the process of their validation.
SKB TR 91-23

The background and objectives of the project are presented in a background report to SKB R&D programme 1989 (Hard Rock Laboratory) where a detailed description of the HRL project can be found.

1 INTRODUCTION

Pre-investigations for the Äspö Hard Rock Laboratory have been in progress since late 1986. The Pre-investigation stage has now been terminated and the construction phase started in October 1990. The regional investigation area is about 25 x 35 km (Fig.2-1).

The aim of this report is to compile all the pre-investigations performed for the HRL. In the first part (chapter 2) of the report all the different pre-investigations are listed in chronological order (Table 2-1, 2-2 and 2-3) with figures and references. The second part of the report (chapter 3) comprise an overview of information about all the boreholes performed.

Most of the data are presented in CAD-generated maps and illustrations. The compilation has been edited by Roy Stanfors, and performed by Mikael Erlström and Ingemar Markström.

2. GENERAL OVERVIEW

The nextcoming chapters (2.1-2.3) give an introduction to tables 2-1, 2-2 and 2-3, and figures 2-1 to 2-16. The figure illustrations give further information concerning the scope of work performed during the different investigations. The main issue for the performed investigations are given in the tables.

2.1 PRE-INVESTIGATION - SITING STAGE

The pre-investigations started with a regional survey comprising many different methods (magnetic, coaxial EM, Radiometric and two stations VLF). A gravity measurement and some ground geophysical profiles (magnetic and VLF) complemented the aerogeophysical survey on the island of Ävrö and Äspö and in the Laxemar area.

Lineaments in the Simpevarp area were interpreted from different digital terrain models and the solid rock was mapped to a scale of 1:10 000 in an area nearest to Simpevarp and to a scale of 1: 50 000 in a larger, outer area. Fracture mapping and special tectonic studies were carried out with the main goal of describing the geometry of the fractures and characterizing the main sets of tectonic zones identified as lineaments in the area.

An analysis was made of regional well data from SGU Well Records and a compilation made of geohydrological data from the pre-investigations and construction works for the power plant and the CLAB interim storage

facility, all in the Simpevarp area. Chemical data in SGU Well Records were used to define the composition of the shallow ground water in Kalmar County.

The investigation methods used in the first regional stage and the main issue of the surveys are presented in table 2-1 and figures 2-1, 2-2 and 2-3.

2.2 PRE-INVESTIGATION - SITE DESCRIPTION STAGE

During the investigations in 1987 drilling was performed at different phases in the areas of Ävrö, Äspö and Laxemar. A number of percussion boreholes were drilled to obtain preliminary information of the bedrock composition and the hydraulic properties of the shallow portion of the bedrock. The shallow groundwater chemistry was analyzed as well. On Äspö 12 percussion boreholes were drilled, at Laxemar seven holes, and on Ävrö four holes.

Three core boreholes (KAS 02, KAS 03 and KAS 04) were based on a preliminary geological and geohydrological model of Äspö core boreholes. KLX 01 in the central part of a major block in the Laxemar area was drilled as a reference hole.

The solid rock on Äspö has been mapped to a scale of 1:2 000.

A very detailed study was made along cleaned trenches across the island. A detailed structural analysis was made of terrain features on Äspö, based on the study of topographical maps to a scale 0f 1:4 000, and with a contour interval of 1.0 m. Maps showing lineaments and rock blocks of different orders are presented.

A fracture mapping programme was executed on outcrops following the cleaned trenches. It includes geographically integrated results regarding strikes, dips and fracture densities, lengths and spacing.

In order to investigate and delineate the local tectonic setting of the island of Äspö, detailed magnetic and electric mapping of the entire island was carried out during the autumn of 1988. Ground radar measurements were performed on the southern part of Äspö.

Transient interference pump tests were performed in boreholes KAS 02 and KAS 03, and from these major hydraulic conductors were identified. The surface hydrology of the Simpevarp area was compiled to provide basic input.

Detailed groundwater chemical analyses were made on the water sampled from conductive sections of boreholes KAS 02, 03, 04 and KLX 01. Additionally, percussion boreholes on Äspö, Laxemar and Ävrö were sampled in order to provide background information on the composition of shallow groundwater.

The methods used for the local scale investigations are presented in figure 2-12 and table 2-2.

2.3 PRE-INVESTIGATION - PREDICTION STAGE

Based on the results from the local investigations the southern part of Äspö was selected as the most suitable location for the HRL. Four additional core boreholes were directed towards indicated zones of geological and hydraulic importance. They were drilled to a vertical depth of approximately 500 m. Short term interference tests and a long term pumping test were made to find out the hydraulic connections in the rock mass.

The results of the site scale investigations are presented in figures 2-13 to 2-16 and table 2-3.

Due to the change in layout, in which the entrance to the tunnel was moved to the Simpevarp area, a complementary drilling programme was executed. KAS 09, 10, 11 and 14 were drilled to give information on the indicated fracture zones to the south of Äspö. An almost horizontal core borehole, KBH 02, was drilled from Hålö-Äspö, approximately parallel to the tunnel (Fig.2-14)

The percussion boreholes, HAS 18, 19, 20, and two more boreholes, KAS 12, 13, were performed in order to improve the knowledge about the main fracture zones on southern Äspö.

Table 2 – 1
Preinvestigation – siting stage
Regional Scale 25 x 35 km

Investigation method	Main issue of the Survey
AERIAL GEOPHYSICAL SURVEY (Fig. 2-1) PR 25-87-04, PR 25-87-23	
– Magnetic	Bedrock and tectonic interpretation
– Co-axial EM (slingram)	Fracture zone interpretation
– VLF (two station, GQD and JXZ)	Fracture zone (waterbearing) interpretation
– Radiometric (U, Th, K)	Bedrock interpretation
GROUND GEOPHYSICS (Fig. 2-1) PR 25-87-20, PR 25-89-13, PR 25-89-23	
– Gravity (one station per km2)	Bedrock interpretation
– Magnetic and VLF profile measurements	Investigation of aeromagnetically indicated lineaments.
– Seismic refraction	-"-
PETROPHYSICS (Fig. 2-1) PR 25-88-06	
– Density, magn. suscept., magn, remanence, resistivity, IP, porosity. (257 rock samples)	Bedrock interpretation
LINEAMENT ANALYSIS (Fig. 2-2) PR 25-87-21	Fracture zone interpretation
MAPPING OF SOLID ROCKS, 1:50 000 (Fig. 2-2) PR 25-87-02	Distribution and characterization of the main rock units.
TECTONIC ANALYSIS - FRACTURE MAPPING (Fig. 2-2) PR 25-87-03, PR 25-87-05	Characterization of the main tectonic zones. Description of the general fracture pattern.
REGIONAL HYDROLOGY (Fig. 3)	
– Compilation of available data in databases and reports PR 25-87-09	Precipitation, evaporation, run-off and groundwater recharge.
GEOHYDROLOGY (Fig. 2-3)	
– Compilation of available data in SGU-well database. PR 25-87-07	Groundwater chemical composition and the specific capacity of wells in relation to the rocktype and the subareas.
Well water chemical records (Fig. 2-3) PR 25-87-08	Define the variation of the well water composition correlated to the bedrock and the hydraulic properties.

Table 2 – 2
Preinvestigation – siting stage
The Ärsvö, Äspö, Laxemar and Glostad areas

Investigation method	Main issue of the Survey
STRUCTURAL ANALYSIS (Fig. 2-4) PR 25-87-22, PR 25-87-27	Fracture zone interpretation
MAPPING OF SOLID ROCKS, 1:10 000 (Fig. 2-4) PR 25-87-02, a	Bedrock Description
STRUCTURAL GEOLOGICAL ANALYSES (Fig. 2-4) PR 25-88-05	Structural geological characterization.
GROUND GEOPHYSICS (Fig. 2-4, 5) PR 25-87-01, PR 25-87-14, PR 25-87-16, PRAV 77/1, PR 25-88-16	Fracture zone interpretation
– Magnetic	Fracture zone interpretation (vertical or almost vertical)
– VLF	-"-
– Slingram	-"-
– Seismic refraction (Fig. 2-6) PR 25-87-15	-"-
– Seismic reflection (Fig. 2-6) PR 25-89-02 PR 25-87-14	Fracture zone interpretation (sub-horizontal)
DETAILED GEOLOGICAL MAPPING (Fig. 2-7) PR 25-88-12	Detailed petrological description of rocks
DETAILED GEOPHYSICAL INVESTIGATION (Fig. 2-7) PR 25-88-16, PR 25-89-01, PR 25-89-12	Delineate the local pattern of fracture zones
DETAILED STUDY OF GEOLOGICAL STRUCTURES AND TECTONIC HISTORY. (Fig. 2-7) PR 25-88-05 PR 25-89-11, PR 25-89-15	Understanding the geological history of the rocks and to study the main sets of the tectonic zones.
FRACTURE MAPPING STUDY (Fig. 2- 7) PR 25-88-10	Obtain data for use in geo-hydrological and rock mechanics model studies.
FIRST DRILLING PROGRAMME (Fig. 2-8, 9), PR 25-88-03, PR 25-88-06, PR 25-88-07, PR 25-88-11, PR 25-88-15, PR-25-88-18, PR-25-89-10, PR 25-88-17	Obtain preliminary information on the bedrock composition and the hydraulic properties of the shallow portion of the bedrock.
– HAS 01-12 (percussion boreholes)	Test the first geological model of the island of Äspö.
– HAV 01-04, 07 HLX 01-07 KAS 01-04 (core boreholes)	Obtain basic information on the bedrock composition, orientation and characteristics of the local fracture zones and the hydraulic properties of the rock mass at increasing depth.

The Ävrö, Äspö, Laxemar and Glostad areas (cont.)

Investigation method	Main issue of the Survey
– Geophysical logging	
– Core logging	
– TV-orientation	
– Fracture mineral study	
– Rock stress measurement	
GEOHYDROLOGY (Fig. 2-10)	
– Compilation of available data from reports mainly concidering CLAB and OHI. PR 25-87-10	Hydraulic conductivity of the bedrock and common fracture directions.
HYDRAULIC TESTS IN PERCUSSION BOREHOLES (Fig. 2-10)	
– Drilling records, air-lift tests and pumping tests	Find conductive parts and the specific capacity of the boreholes. Determine the transmissivity and preliminary indications of hydraulic structures.
PR 25-87-11, PR 25-87-11, PR 25-88-14	Preinvestigation – site description stage

The Äspö – Hålö area

Investigation method	Main issue of the Survey
HYDRAULIC TESTS IN CORE BOREHOLES (Fig. 2-10)	
KAS 01-04	
– Air-lift tests PR 25-88-14	Transmissivity of a part of or the whole borehole.
– Pumping tests PR 25-88-14	Clean up the boreholes. Pumping for the spinner survey and estimating the transmissivity of the whole borehole. Preliminary indications of hydraulic structures.
– Spinner survey PR 25-88-14	Identification of hydraulic conductors intersecting the borehole and flow distribution in the borehole.
– Injection tests with packers (3 m and 30 m test interval) PR 25-88-14	Hydraulic conductivity of the bedrock in a small scale.
– Interference tests, pumped sections limited by packers. Six tests in KAS 03 and three in KAS 02. PR 25-88-13	Identification of important hydraulically conductive zones and their transmissivity.

The Äspö – Hålö area (cont.)

Investigation method	Main issue of the Survey
COMBINED EVALUATION OF GEOLOGICAL, GEOHYDROLOGICAL AND GEOPHYSICAL INFORMATIONS (Fig. 2-10)	Find correlation between geological, geohydrological and geophysi al data.
PR 25-89-03	Examine the distribution of some of the parameters along the boreholes and the correlation between the boreholes. Evaluate how to optimize the hydrogeological investigation. Present information for the conceptual model.
PIEZOMETRIC HEAD MEASURMENTS PR 25-90-18	
NUMERICAL GEOHYDROLOGICAL SIMULATIONS (Fig. 2-10)	
– 3-D model PR 25-87-12	Evaluate the hydraulic heads and inflow to tunnels for two proposed design alternatives of the rock laboratory.
– 2-D vertical profile model PR 25-88-17	Examine the influence of the laboratory to decide the size of the 3-D model.
– 3-D model. PR 25-88-17	Examine different boundary conditions.
– 2-D vertical profile model including density dependent flow PR 25-88-02	Examine the interface between fresh groundwater and saline water below an island for a few cases with different sets of hydraulic conductivities.
– 2-D vertical profile model including density dependent flow and random distributed hydraulic conductivities. PR 25-88-09	Examine the salinity stratification and flow field due to random distributed hyraulic conductivities with a given statistical distribution.
– 3D-FE-model PR 25-89-05	Sensitivity analysis of boundary conditions and structure properties.
FRACTURE MINERAL STATISTICS PR 25-88-11	Define the special variation in fracture minerals in correlation to hydraulic properties.
GROUNDWATER SAMPLING FROM SHALLOW PERCUSSION BOREHOLES. pr 25-88-04 (Fig. 2-11)	Define the character of the groundwater in the upper most 100 m part of the bedrock. Characterize the chemical composition of the deep groundwater.
SAMPLING AND ANALYSES OF GROUNDWATER FROM DEEP CORE DRILLED BOREHOLES PR 25-89-04 (Fig. 2-11)	Define the chemistry and the radioactivity of the surface water in the area.
SAMPLING AND ANALYSES OF SURFACE WATER PR 25-88-08	

Table 2 – 3
Preinvestigation – prediction stage
Äspö – Hålö

Investigation method	Main issue of the Survey
SECOND DRILLING PROGRAMME PR 25-89-07, PR 25-89-08, PR 25-89-09, PR 25-89-10, PR 25-89-16, PR 25-89-17 (Fig. 2-12)	Test the second geological model of southern Äspö.
– KAS 05-08	Obtain information of the rock distribution at depth.
– HAS 13-17	Obtain more detailed information on orientation and characteristics of the local fracture zones including hydraulic properties.
– Geophysical logging	
– Core logging	
– Rock stress measurement	
– VSP	
– Tele-viewer-orientation	
– Fracture mineral study	Fracture zone orientation Fracture orientation
SEISMIC REFRACTION (Fig. 2-6) PR 25-89-18	Detailed identification of supposed narrow fracture zones.
FRACTURE MINERAL STATISTICS PR 25-89-16	Define the special variation in fracture minerals in correlation to hydraulic properties.
SAMPLING AND ANALYSES OF GROUNDWATER FROM DEEP CORE-DRILLED BOREHOLES PR 25-89-14 (Fig. 2-11)	Characterize the chemical composition of the deep groundwater.
CHEMICAL ANALYSES OF FRACTURE MINERALS IN CONDUCTIVE FRACTURES	To classify the chemical conditions in the fracture minerals of conducting fractures in order to be able to model the groundwater-fracture mineral reactions. Southern Äspö.
HYDRAULIC TESTS, SECOND DRILLING PROGRAMME (Fig. 2-12) PR 25-89-20, PR 25-90-09	
– Drilling records, air-lift tests, HAS 13-17	see second phase, "Hydraulic tests"
– Airlift test, KAS 05-08	- " -
– Pumping tests, KAS 05-08	- " -
– Spinner survey, KAS 06-07	- " -
– Injection tests with packers (3 m test interval), KAS 05-08	- " -
– Interference tests, four in KAS 06 one in HAS 13	- " -
– Longtime pumping test, KAS 07	Identification of important hydraulically conductive zones, their transmissivity and boundary conditions.

Table 2 – 3 (cont.)

Investigation method	Main issue of the Survey
NUMERICAL GEOHYDROLOGICAL SIMULATIONS (Fig. 2-12)	
3D-FE-model PR 25-90-04	Prediction of the longtime pumping test in kas 07
3D-FD-model PR 25-90-03	-"-
A1 (see sep)	- " -
THIRD DRILLING PROGRAMME (Fig. 2-13, 14) PR 25-90-05, PR 25-90-06, PR 25-90-07, PR 25-90-08	Localize and characterize fracture zones in the tunnel area. Hålö-Äspö.
– KBH 01-02 (Fig. 2-14)	Get more detailed information concerning the fracture zones EW-1 and NE-2.
– KAS 09-14 (Fig. 2-13)	
– HAS 18-20 (Fig. 2-13)	
– Geophysical logging	
– Core logging	
HYDRAULIC TESTS, THIRD DRILLING PROGRAMME (Fig. 2-13, 14)	
– Drilling records, air-lift test	see second phase, "Hydraulic tests"
HAS 18-20, pumping test in HAS 20	- " -
– Air-lift tests, KAS 09-14, KBH 01-02	- " -
– Pumping tests, KAS 09, 11-14 KBH 02	- " -
– Spinner survey, KAS 09, 11-14	
GROUNDWATER SAMPLING AND ANALYSES	Define salinity of the groundwater in conductive zones.
SEISMIC REFRACTION (Simpevarp - Hålö-Äspö) (Fig. 2-6) PR 25-89-18	
DETAILED ELECTRIC AND MAGNETIC INVESTIGATION (Hålö-Äspö) (Fig. 2-15) PR 25-89-19, PR 25-89-22	- " -

Table 2 – 3 (cont.)

Investigation method	Main issue of the Survey
DISCRETE FRACTURE MODELLING	
PR 25-89-21	Generic modelling of the flow through a 50 m cube. The object was to test discrete fracture flow modelling.
NUMERICAL GEOHYDROLOGICAL SIMULATIONS	
– 3D + FD model PR 25-90-10	Preliminary predictions of the long time pumpingtest in KAS 06 performed as a tracer test. Model based on a preliminary conceptual model.
– 3D + FD model PR 25-90-11	Preliminary predictions of the drawdown and the inflow to the tunnel during the excavation of the Äspö HRL. Model based on a preliminary conceptual model.
– 3D + FD model PR 25-91-03	Predictions of the drawdown and the inflow to the tunnel during the excavation of the Äspö HRL. Model based on the conceptual model 1990.
GEOHYDROLOGY	
– Work up measured data. PR 25-91-16a PR 25-91-16b	Evaluate and reevaluate measured data and present theoretical consideration in short text which are successivly presented according to a mail list. The reports are worked up texts.
– Input data for numerical modelling. PR 25-91-17a PR 25-91-17b	Gather and work up the information that is neccessary for the numerical simulations from other reports.

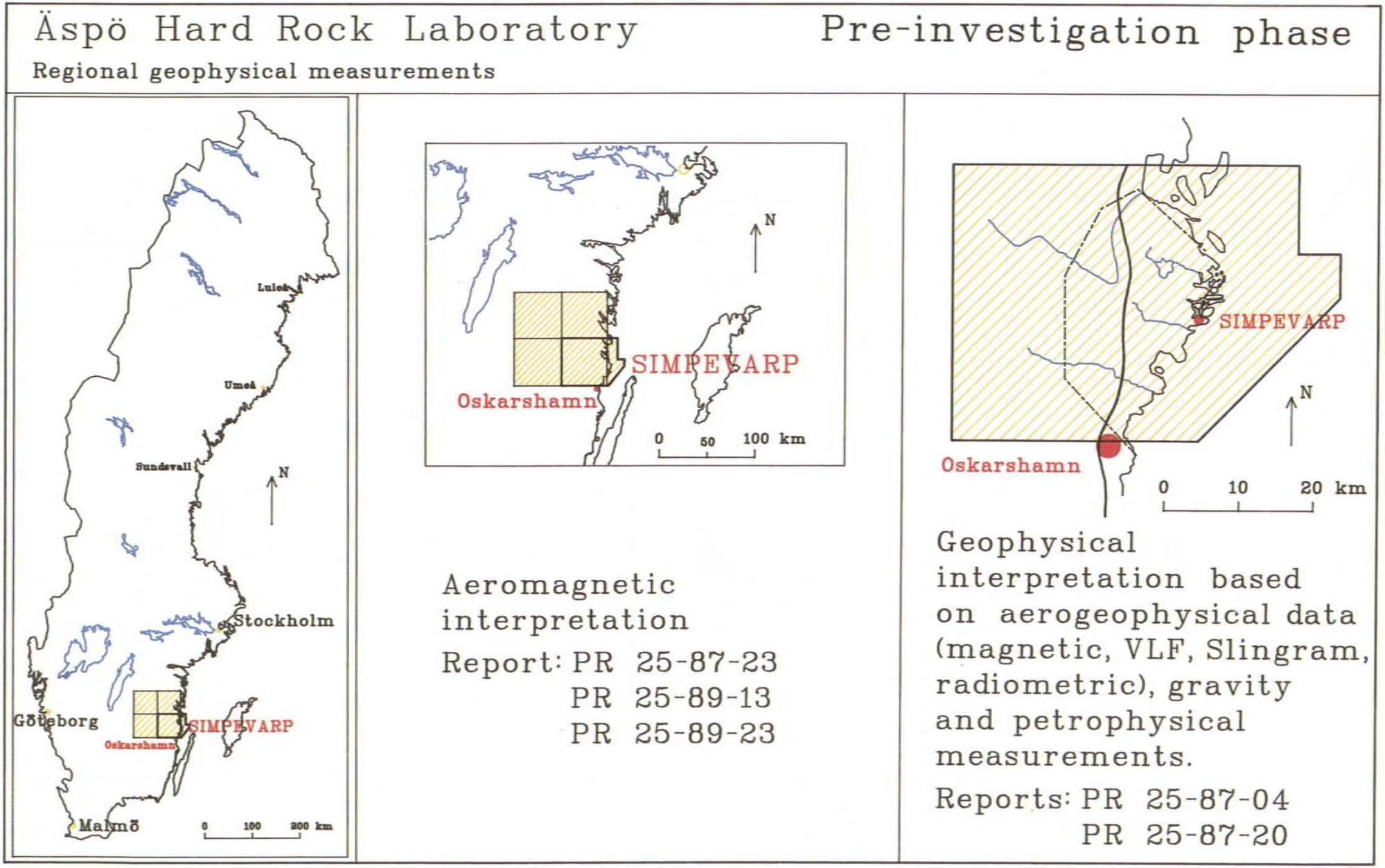

Äspö Hard Rock Laboratory
Pre-investigation phase
Regional geophysical measurements
Luleå
Umeå
Sundsvall
N
Stockholm
Göteborg
SIMPEVARP
Oskarshamn
Malmö
0 100 200 km
N
SIMPEVARP
Oskarshamn
0 50 100 km
Aeromagnetic interpretation
Report: PR 25-87-23
PR 25-89-13
PR 25-89-23
SIMPEVARP
N
Oskarshamn
0 10 20 km
Geophysical interpretation based on aerogeophysical data (magnetic, VLF, Slingram, radiometric), gravity and petrophysical measurements.
Reports: PR 25-87-04
PR 25-87-20

Figure 2-1.

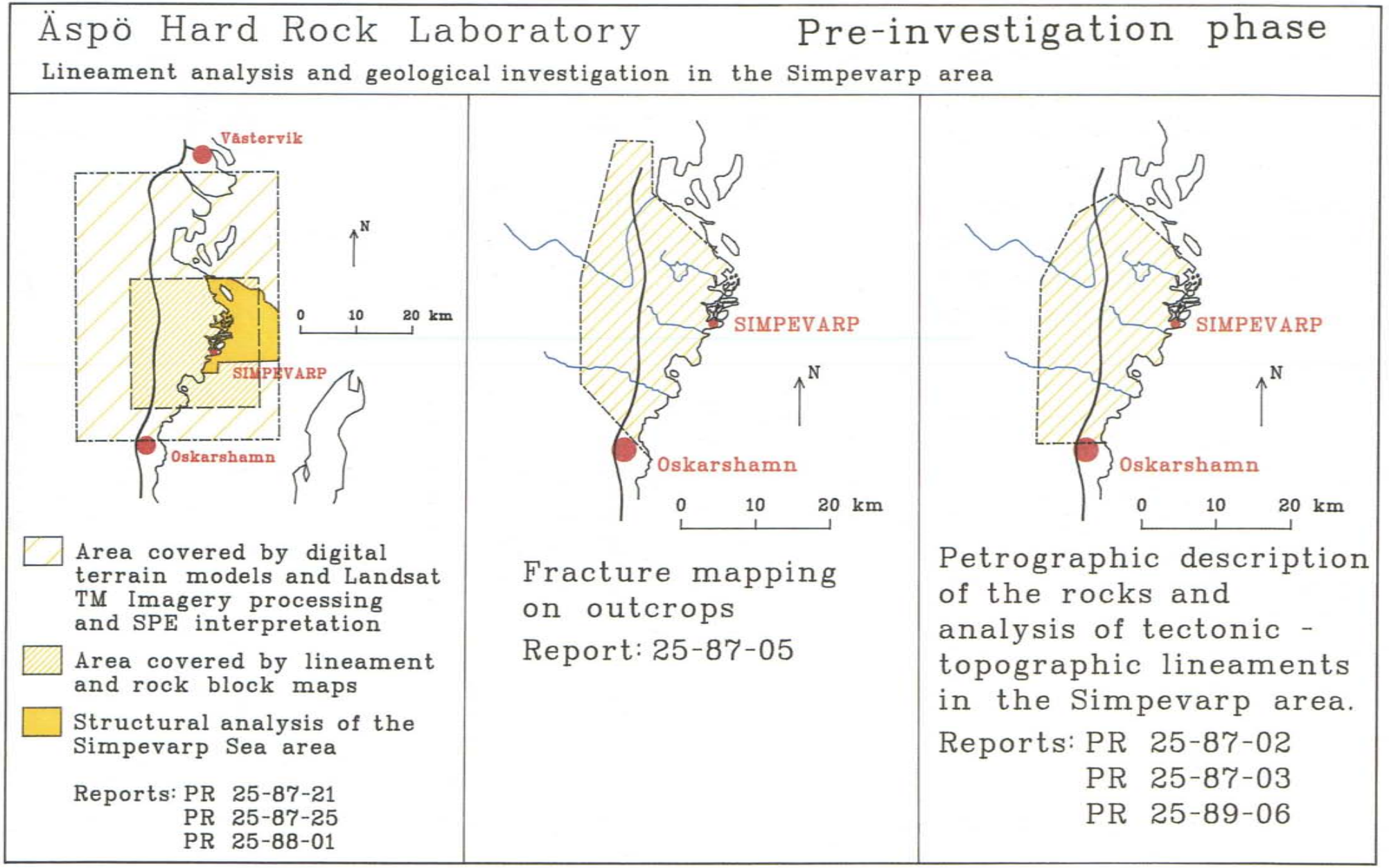

Äspö Hard Rock Laboratory
Pre-investigation phase
Lineament analysis and geological investigation in the Simpevarp area
Västervik
N
0 10 20 km
SIMPEVARP
Oskarshamn
Area covered by digital terrain models and Landsat TM Imagery processing and SPE interpretation
Area covered by lineament and rock block maps
Structural analysis of the Simpevarp Sea area
Reports: PR 25-87-21
PR 25-87-25
PR 25-88-01
SIMPEVARP
N
Oskarshamn
0 10 20 km
Fracture mapping on outcrops
Report: 25-87-05
SIMPEVARP
N
Oskarshamn
0 10 20 km
Petrographic description of the rocks and analysis of tectonic - topographic lineaments in the Simpevarp area.
Reports: PR 25-87-02
PR 25-87-03
PR 25-89-06

Figure 2-2.

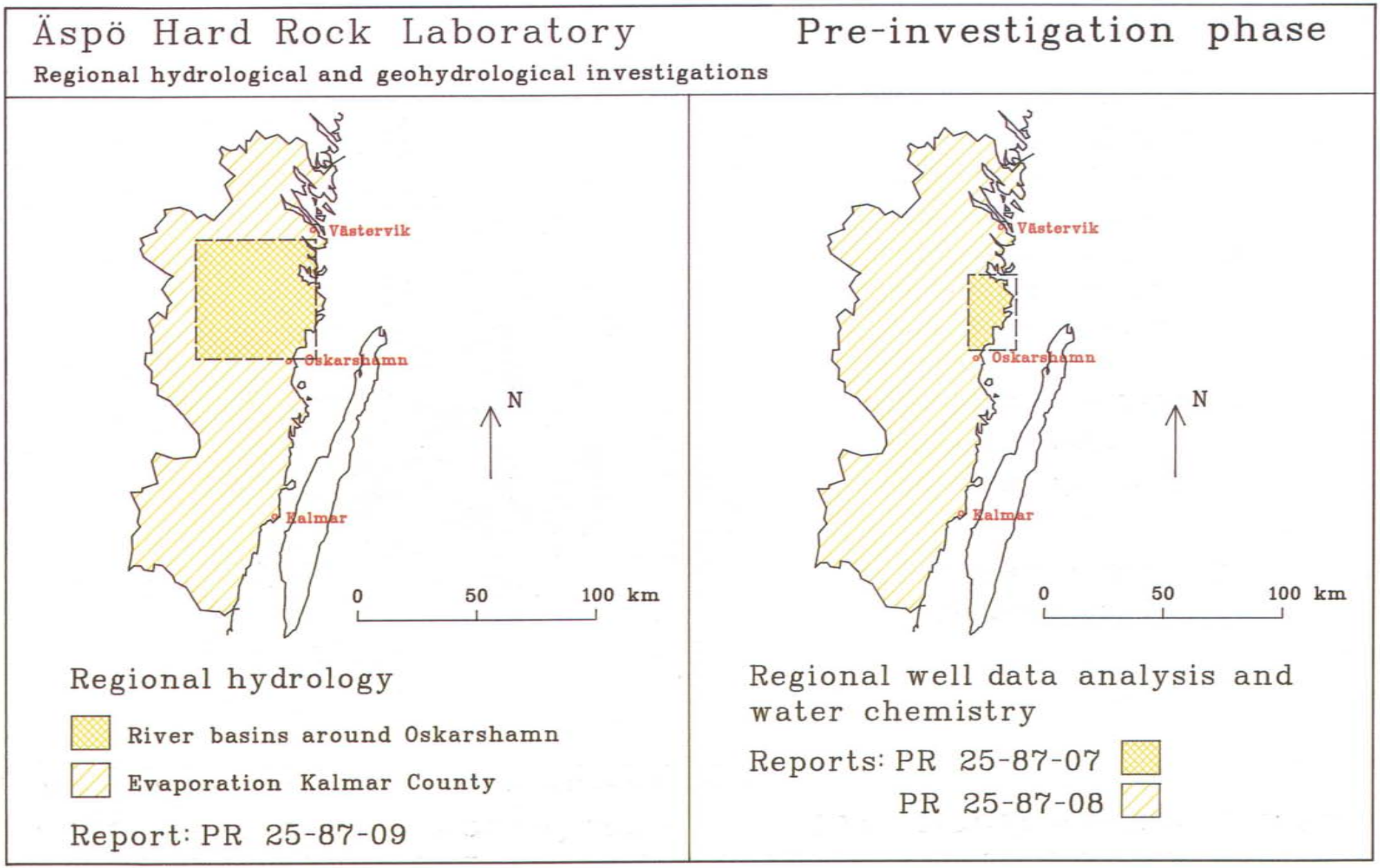

Äspö Hard Rock Laboratory
Pre-investigation phase
Regional hydrological and geohydrological investigations
Västervik
Oskarshamn
Kalmar
N
0
50
100 km
Regional hydrology
River basins around Oskarshamn
Evaporation Kalmar County
Report: PR 25-87-09
Västervik
Oskarshamn
Kalmar
N
0
50
100 km
Regional well data analysis and water chemistry
Reports: PR 25-87-07
PR 25-87-08

Figure 2-3.

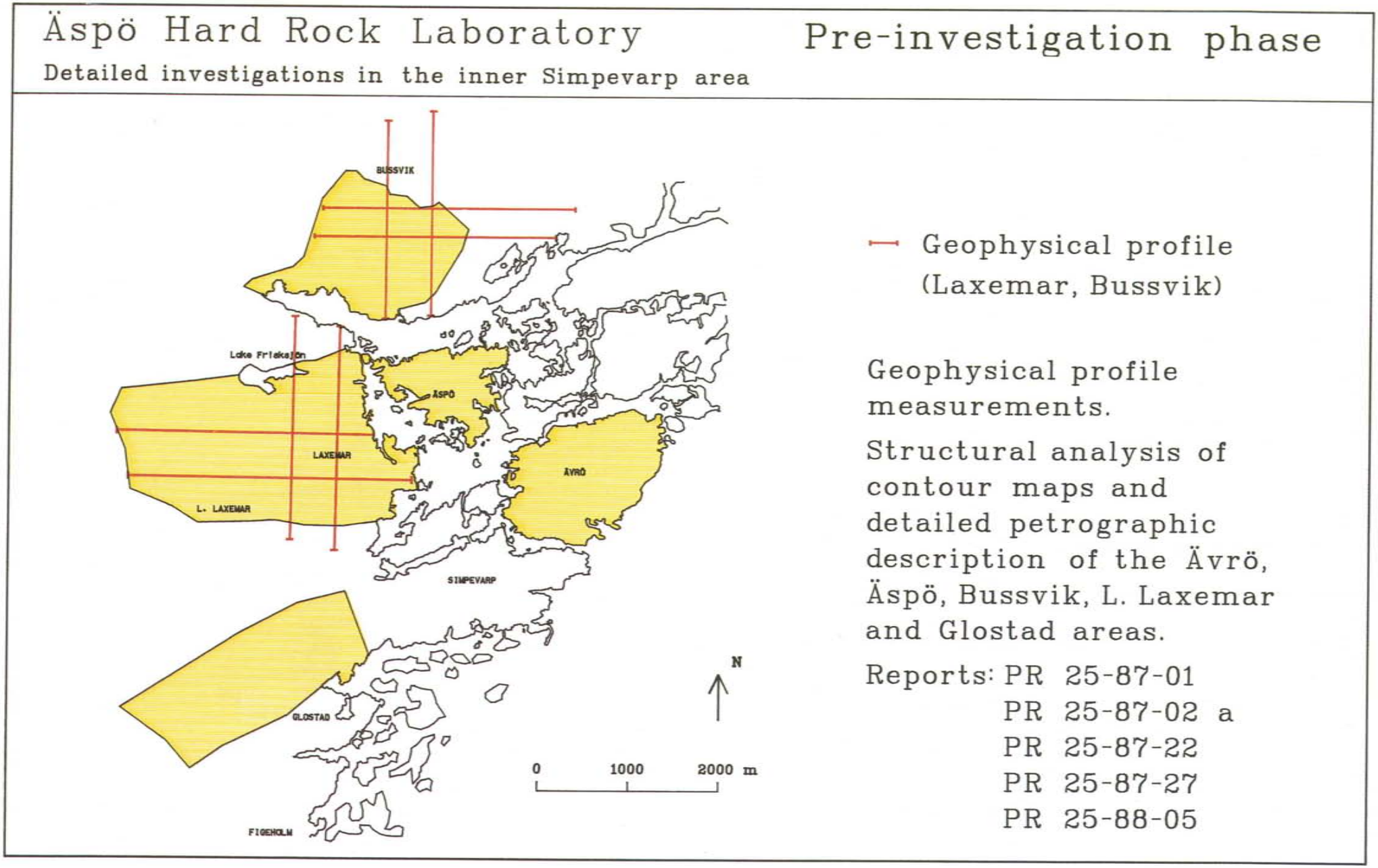

Äspö Hard Rock Laboratory
Pre-investigation phase
Detailed investigations in the inner Simpevarp area
BUSSVIK
Lake Frieksjön
ÄSPÖ
LAXEMAR
L. LAXEMAR
ÄVRÖ
SIMPEVARP
GLOSTAD
FIGEHOLM
N
0
1000
2000 m
Geophysical profile
(Laxemar, Bussvik)
Geophysical profile measurements.
Structural analysis of contour maps and detailed petrographic description of the Ävrö, Äspö, Bussvik, L. Laxemar and Glostad areas.
Reports: PR 25-87-01
PR 25-87-02 a
PR 25-87-22
PR 25-87-27
PR 25-88-05

Figure 2-4.

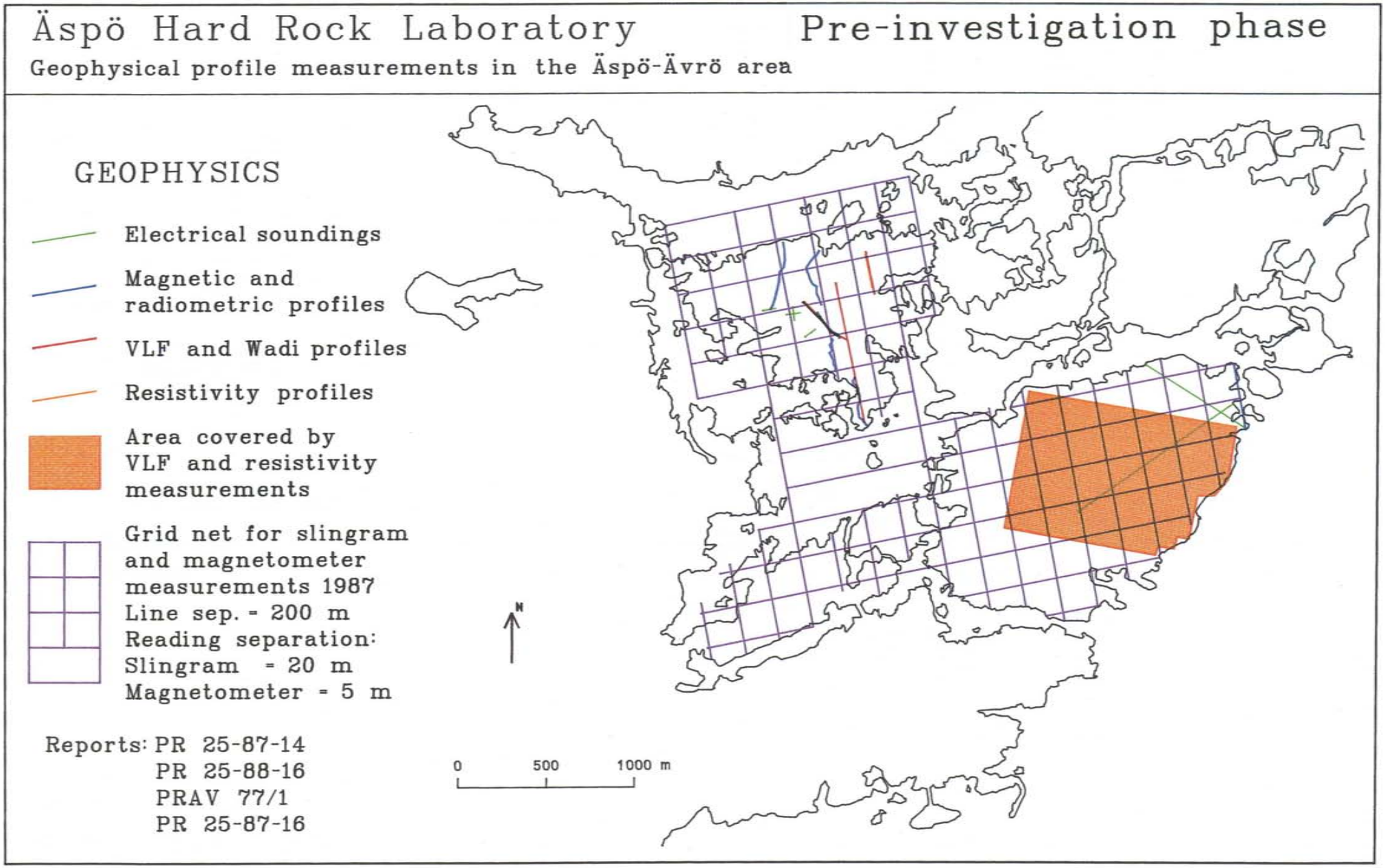

Äspö Hard Rock Laboratory
Pre-investigation phase
Geophysical profile measurements in the Äspö-Ävrö area
GEOPHYSICS
Electrical soundings
Magnetic and radiometric profiles
VLF and Wadi profiles
Resistivity profiles
Area covered by VLF and resistivity measurements
Grid net for slingram and magnetometer measurements 1987
Line sep. = 200 m
Reading separation:
Slingram = 20 m
Magnetometer = 5 m
Reports: PR 25-87-14
PR 25-88-16
PRAV 77/1
PR 25-87-16
N
0
500
1000 m

Figure 2-5.

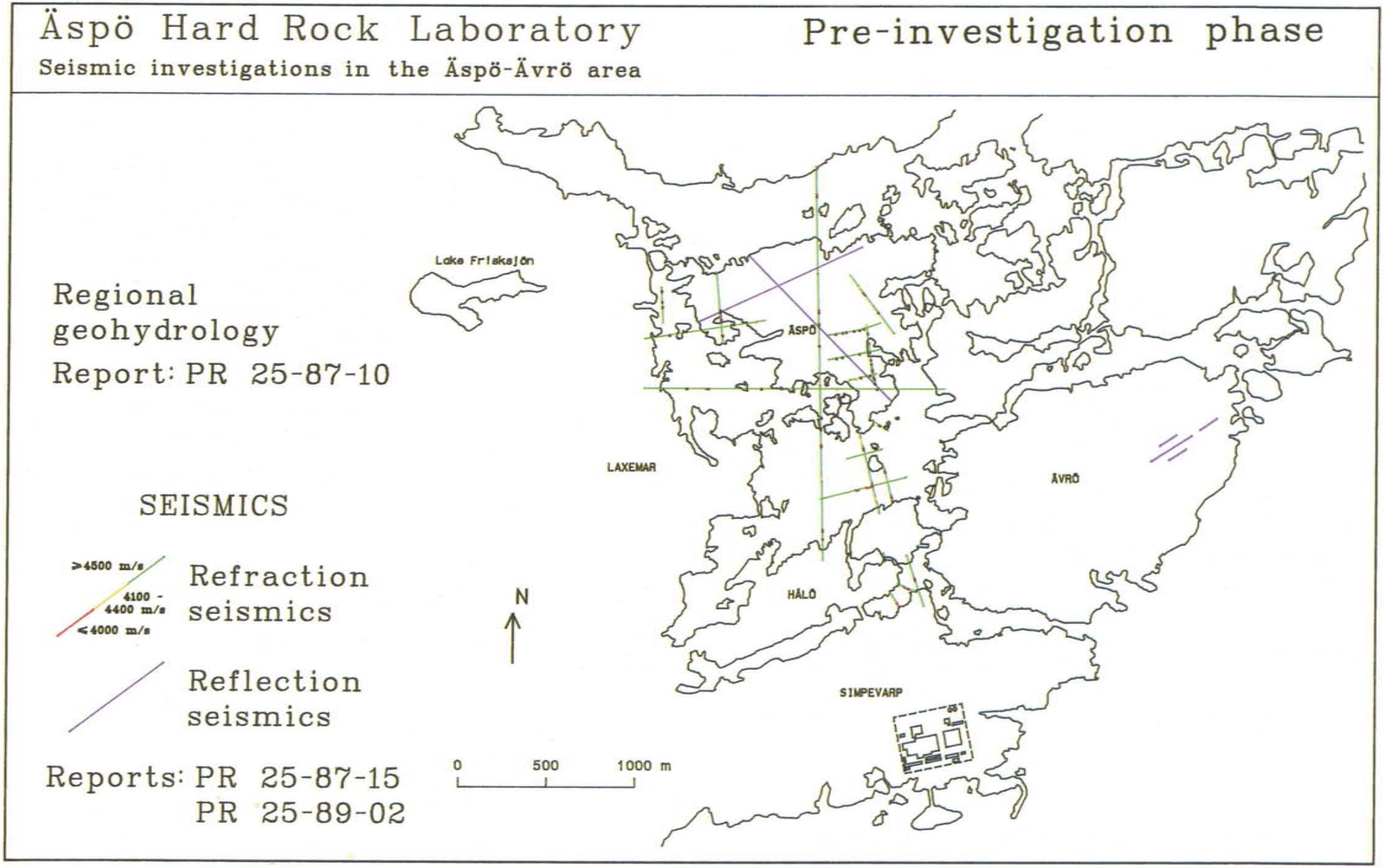
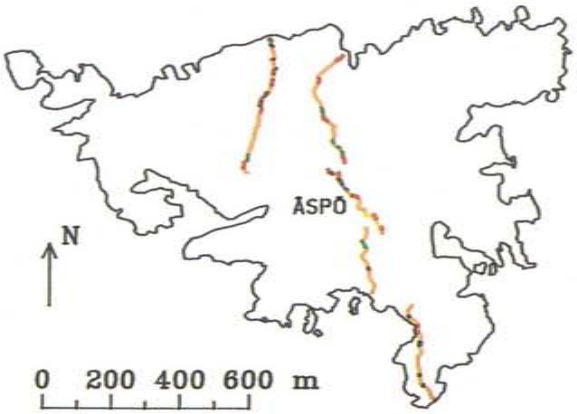

Äspö Hard Rock Laboratory
Pre-investigation phase
Seismic investigations in the Äspö-Ävrö area
Regional geohydrology
Report: PR 25-87-10
SEISMICS
>4500 m/s
4100 - 4400 m/s
<4000 m/s
Refraction seismics
Reflection seismics
Reports: PR 25-87-15
PR 25-89-02
N
0
500
1000 m
Lake Frisksjön
ÄSPÖ
LAXEMAR
ÄVRÖ
HÅLÖ
SIMPEVARP

Figure 2-6.

Äspö Hard Rock Laboratory — Pre-investigation phase

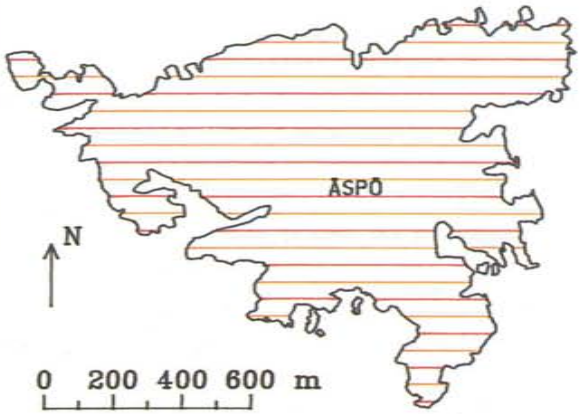
Detailed geological and geophysical investigations on Äspö



Description to detailed maps of solid rocks including 3 cleaned trenches.

- Greenstone
- Äspö diorite
- Granite, fine-grained
- Småland granite
- Mylonite

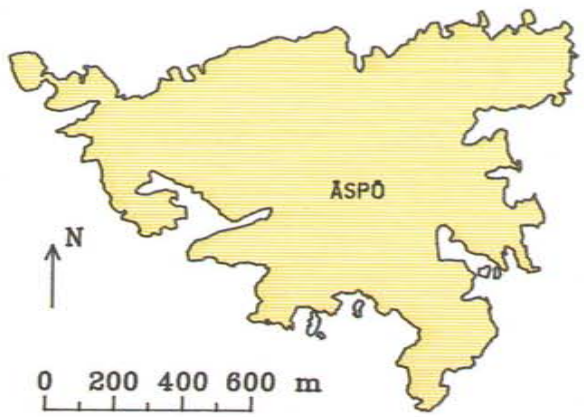
Report: PR 25-88-12



Detailed geomagnetic and geoelectric mapping.

Ground surface radar measurements.

Reports: PR 25-89-01
PR 25-89-12



Detailed study of geological stuctures and tectonic history.

Fracture mapping study.

Reports: PR 25-88-05
PR 25-88-10
PR 25-89-11
PR 25-89-15
PR 25-89-24

Figure 2-7.

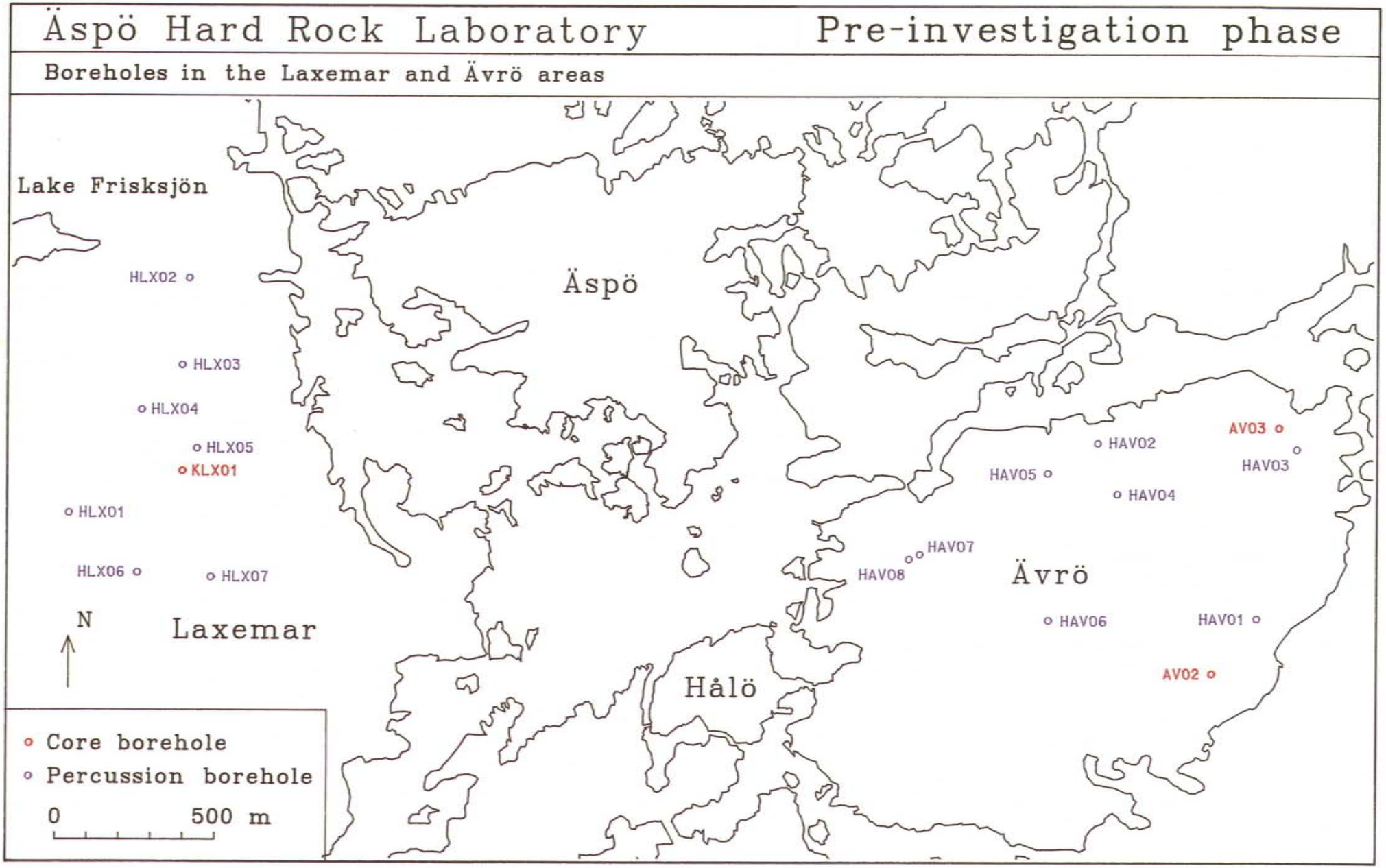

Äspö Hard Rock Laboratory
Pre-investigation phase
Boreholes in the Laxemar and Ävrö areas
Lake Frisksjön
Äspö
HLX02
HLX03
HLX04
HLX05
KLX01
HLX01
HLX06
HLX07
N
Laxemar
Hålö
HAV08
HAV07
HAV05
HAV02
AV03
HAV03
HAV04
Ävrö
HAV06
HAV01
AV02
Core borehole
Percussion borehole
0
500 m

Figure 2-8.

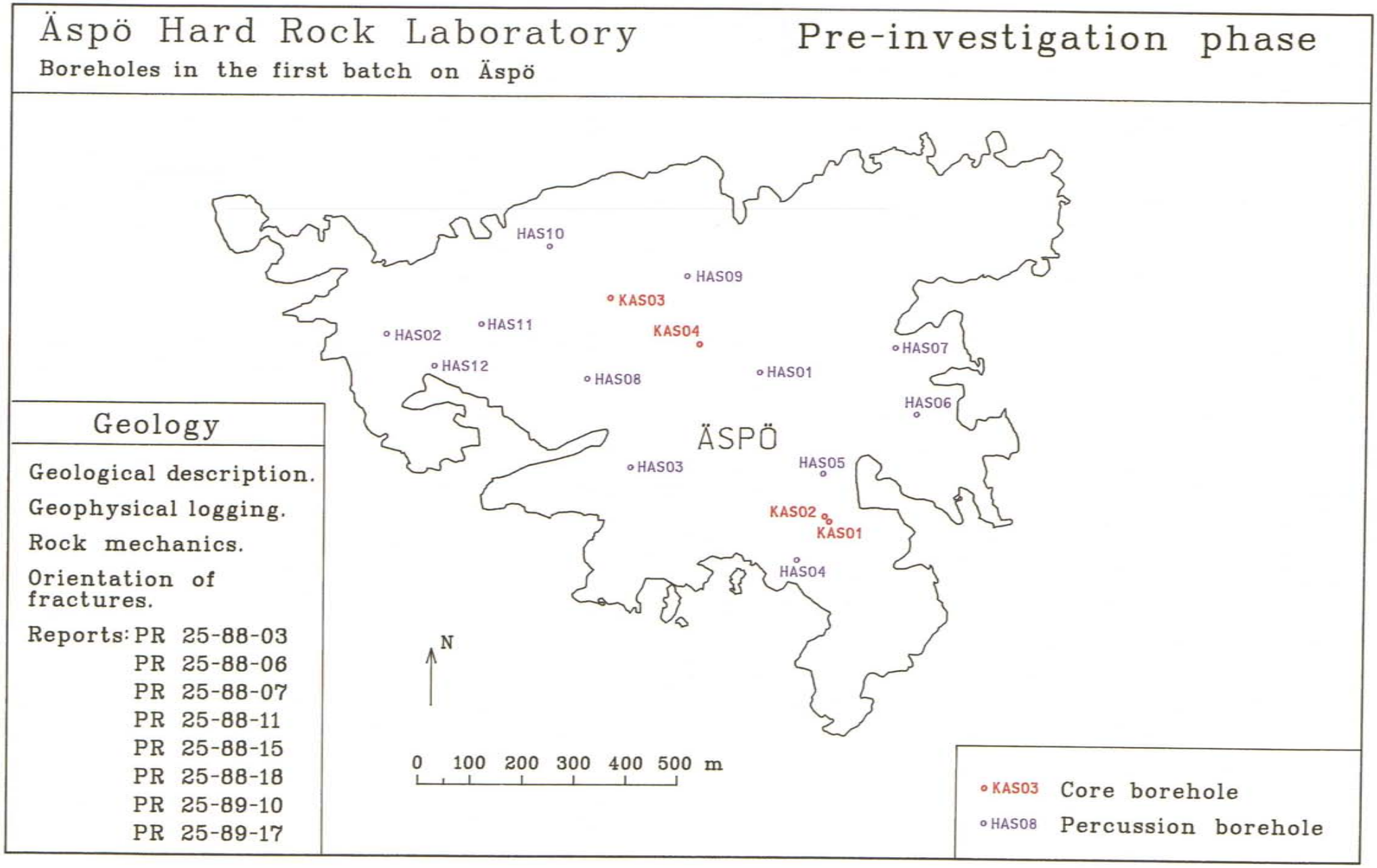

Äspö Hard Rock Laboratory
Pre-investigation phase
Boreholes in the first batch on Äspö
HAS10
HAS09
KAS03
HAS02
HAS11
KAS04
HAS07
HAS12
HAS08
HAS01
HAS06
ÄSPÖ
HAS03
HAS05
KAS02
KAS01
HAS04
N
0 100 200 300 400 500 m
Geology
Geological description.
Geophysical logging.
Rock mechanics.
Orientation of fractures.
Reports: PR 25-88-03
PR 25-88-06
PR 25-88-07
PR 25-88-11
PR 25-88-15
PR 25-88-18
PR 25-89-10
PR 25-89-17
KAS03 Core borehole
HAS08 Percussion borehole

Figure 2-9.

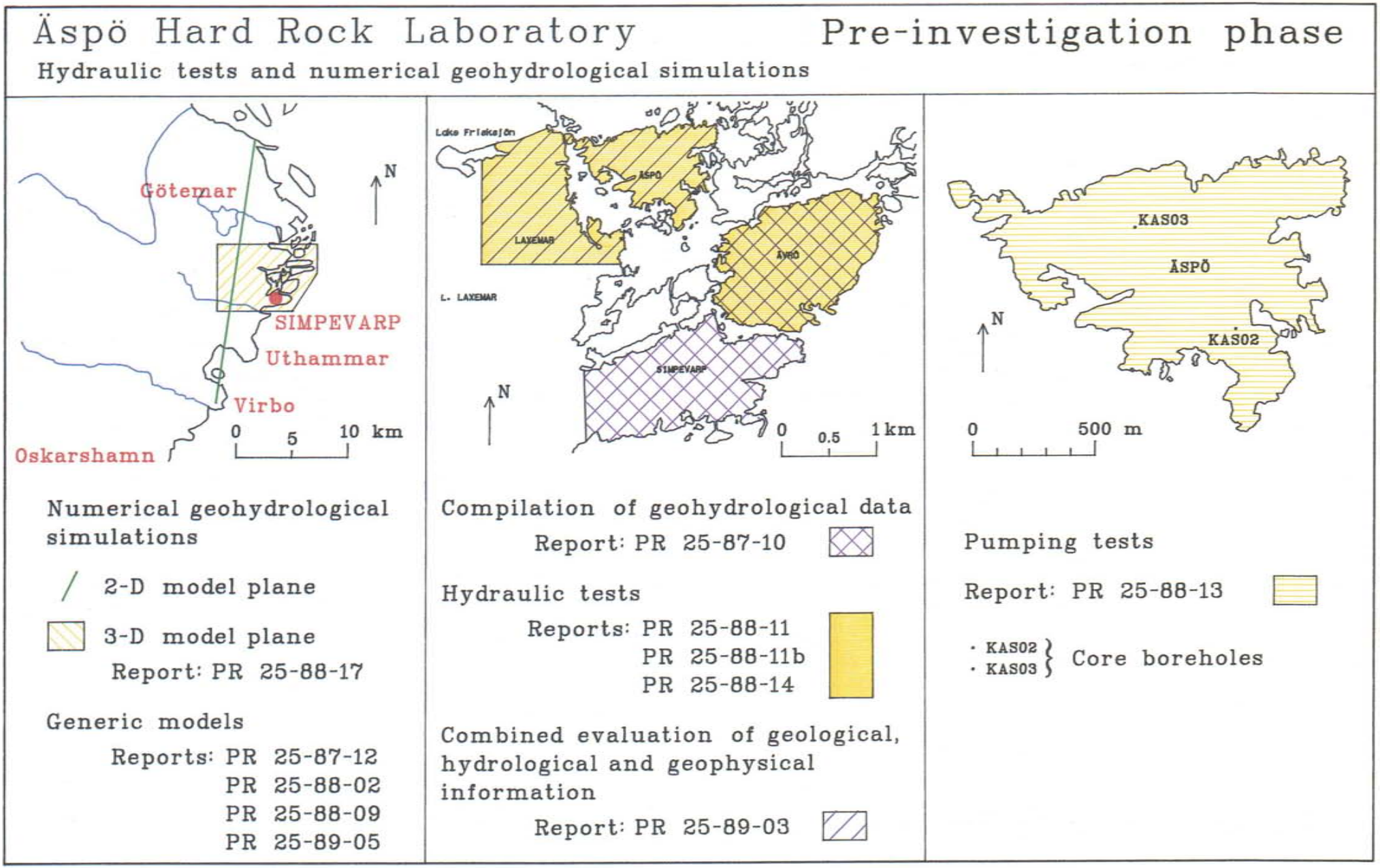

Äspö Hard Rock Laboratory
Pre-investigation phase
Hydraulic tests and numerical geohydrological simulations
Götemar
N
SIMPEVARP
Uthammar
Virbo
0 5 10 km
Oskarshamn
Lake Frisksjön
ÄSPÖ
LAXEMAR
ÄVRÖ
L. LAXEMAR
SIMPEVARP
N
0 0.5 1 km
KAS03
ÄSPÖ
N
KAS02
0 500 m
Numerical geohydrological simulations
2-D model plane
3-D model plane
Report: PR 25-88-17
Generic models
Reports: PR 25-87-12
PR 25-88-02
PR 25-88-09
PR 25-89-05
Compilation of geohydrological data
Report: PR 25-87-10
Hydraulic tests
Reports: PR 25-88-11
PR 25-88-11b
PR 25-88-14
Combined evaluation of geological, hydrological and geophysical information
Report: PR 25-89-03
Pumping tests
Report: PR 25-88-13
KAS02
KAS03
Core boreholes

Figure 2-10.

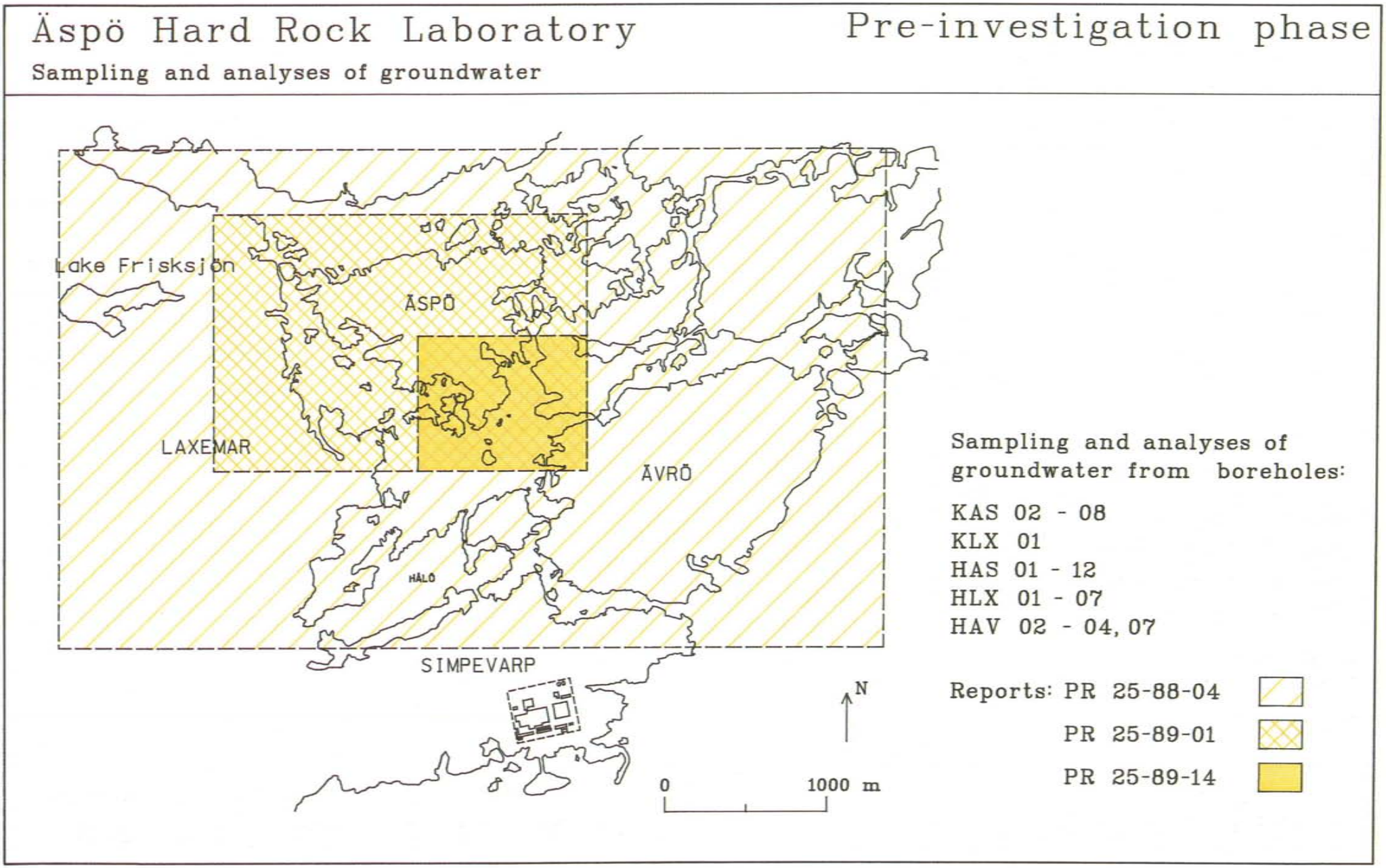

Äspö Hard Rock Laboratory
Pre-investigation phase
Sampling and analyses of groundwater
Lake Frisksjön
ÄSPÖ
LAXEMAR
ÄVRÖ
HÅLÖ
SIMPEVARP
N
0
1000 m
Sampling and analyses of groundwater from boreholes:
KAS 02 - 08
KLX 01
HAS 01 - 12
HLX 01 - 07
HAV 02 - 04, 07
Reports: PR 25-88-04
PR 25-89-01
PR 25-89-14

Figure 2-11.

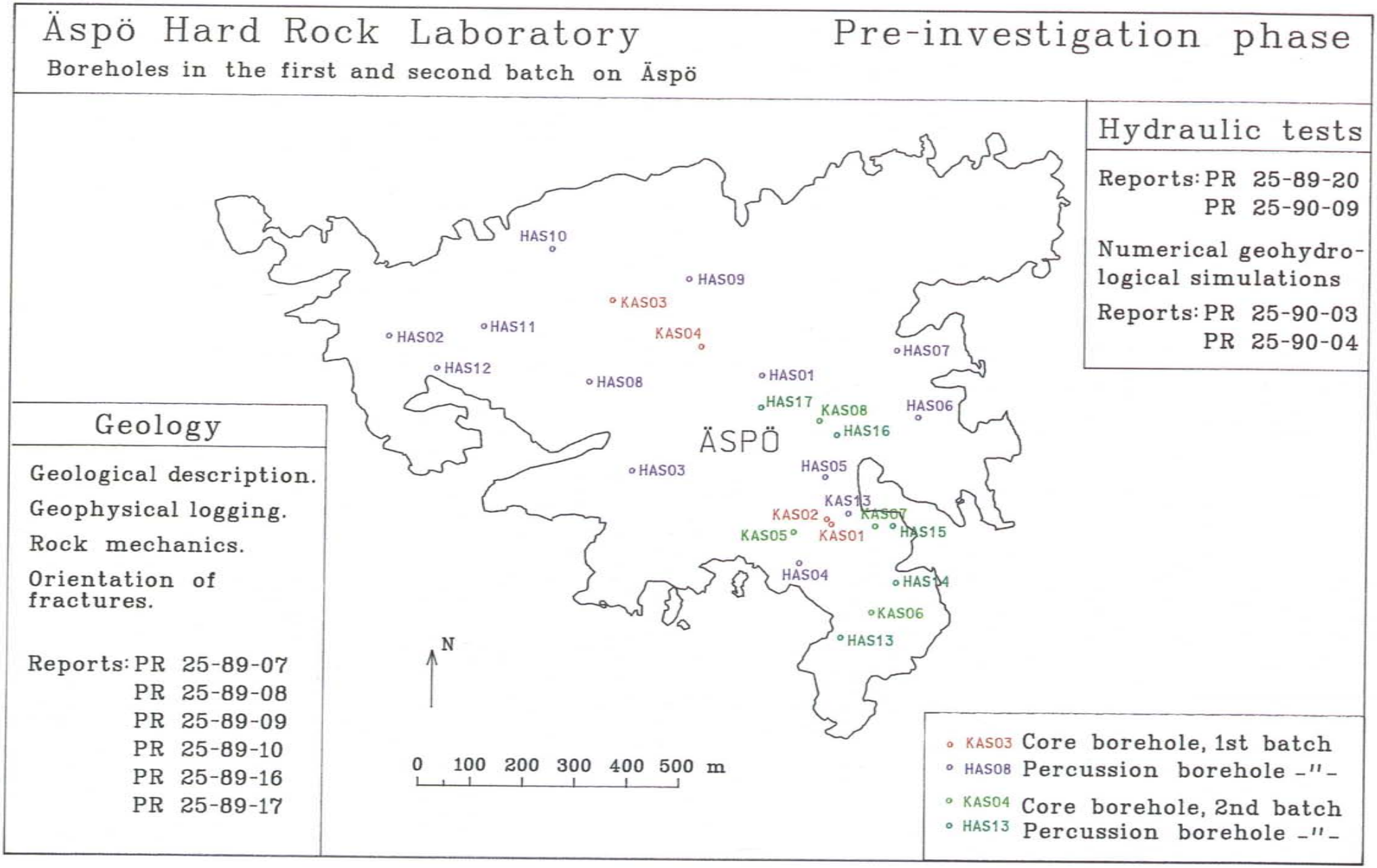

Äspö Hard Rock Laboratory
Pre-investigation phase
Boreholes in the first and second batch on Äspö
Hydraulic tests
Reports: PR 25-89-20
PR 25-90-09
Numerical geohydrological simulations
Reports: PR 25-90-03
PR 25-90-04
Geology
Geological description.
Geophysical logging.
Rock mechanics.
Orientation of fractures.
Reports: PR 25-89-07
PR 25-89-08
PR 25-89-09
PR 25-89-10
PR 25-89-16
PR 25-89-17
ÄSPÖ
HAS10
HAS09
KAS03
HAS02
HAS11
KAS04
HAS07
HAS12
HAS08
HAS01
HAS17
KAS08
HAS06
HAS16
HAS03
HAS05
KAS13
KAS02
KAS07
KAS05
KAS01
HAS15
HAS04
HAS14
KAS06
HAS13
N
0 100 200 300 400 500 m
KAS03 Core borehole, 1st batch
HAS08 Percussion borehole -"-
KAS04 Core borehole, 2nd batch
HAS13 Percussion borehole -"-

Figure 2-12.

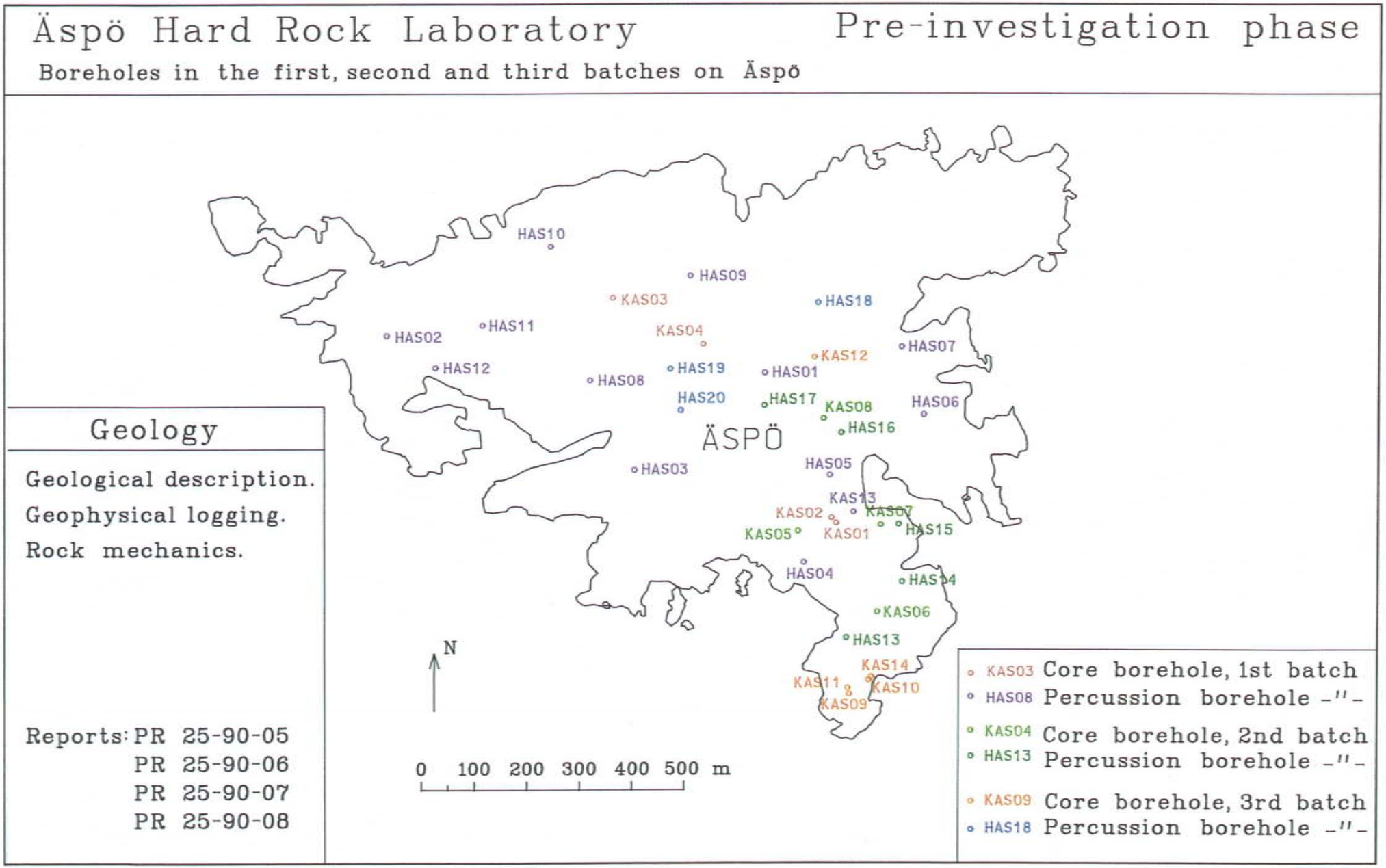

Äspö Hard Rock Laboratory
Pre-investigation phase
Boreholes in the first, second and third batches on Äspö
Geology
Geological description.
Geophysical logging.
Rock mechanics.
Reports: PR 25-90-05
PR 25-90-06
PR 25-90-07
PR 25-90-08
ÄSPÖ
HAS10
HAS09
KAS03
HAS18
HAS02
HAS11
KAS04
HAS07
KAS12
HAS12
HAS19
HAS01
HAS08
HAS20
HAS17
KAS08
HAS06
HAS16
HAS03
HAS05
KAS13
KAS02
KAS07
KAS05
KAS01
HAS15
HAS04
HAS14
KAS06
HAS13
KAS14
KAS11
KAS10
KAS09
N
0 100 200 300 400 500 m
KAS03 Core borehole, 1st batch
HAS08 Percussion borehole -"-
KAS04 Core borehole, 2nd batch
HAS13 Percussion borehole -"-
KAS09 Core borehole, 3rd batch
HAS18 Percussion borehole -"-

Figure 2-13.

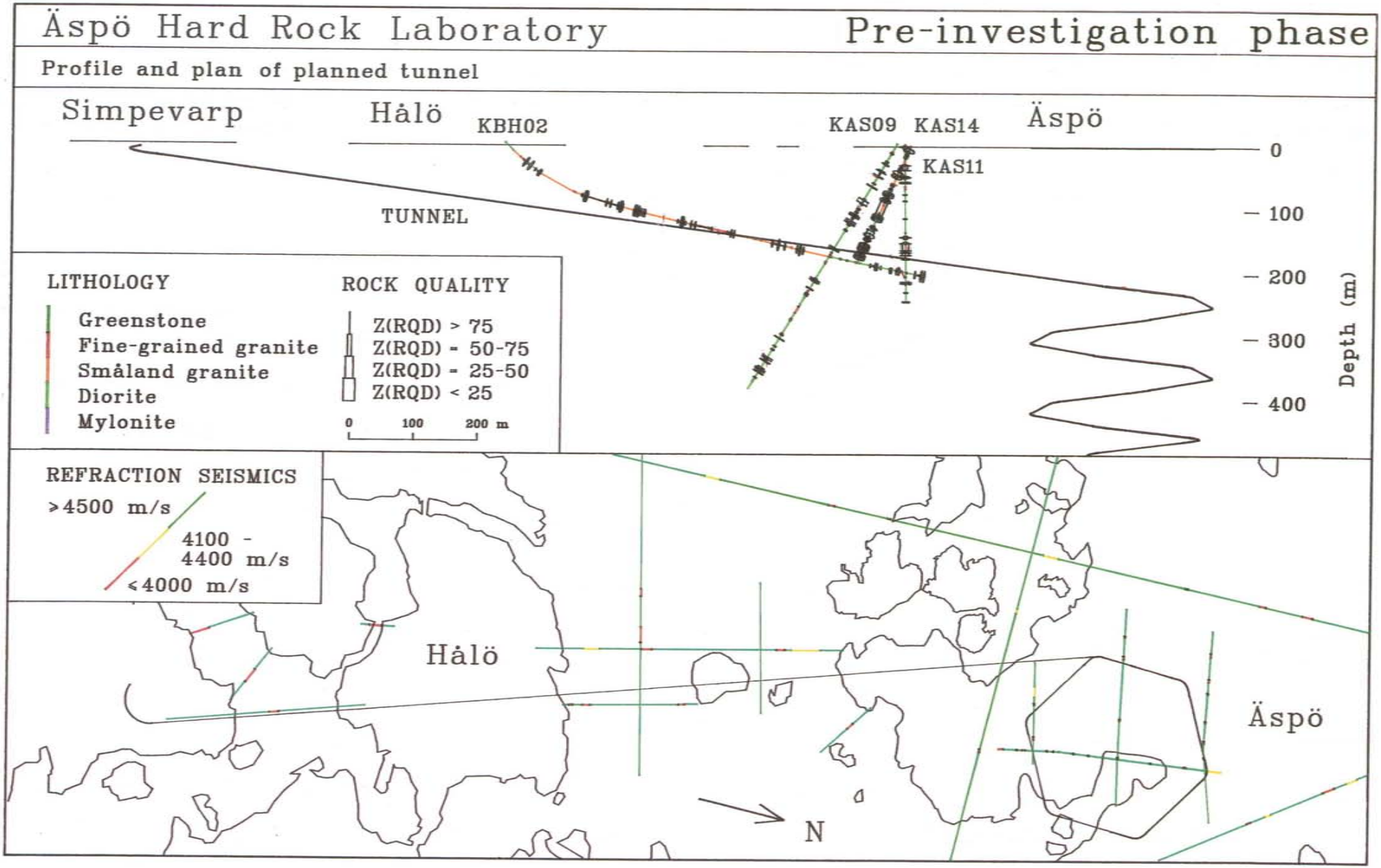

Äspö Hard Rock Laboratory
Pre-investigation phase
Profile and plan of planned tunnel
Simpevarp
Hålö
KBH02
KAS09 KAS14
Äspö
KAS11
TUNNEL
0
100
200
300
400
Depth (m)
LITHOLOGY
Greenstone
Fine-grained granite
Småland granite
Diorite
Mylonite
ROCK QUALITY
Z(RQD) > 75
Z(RQD) - 50-75
Z(RQD) - 25-50
Z(RQD) < 25
0 100 200 m
REFRACTION SEISMICS
>4500 m/s
4100 - 4400 m/s
<4000 m/s
Hålö
Äspö
N

Figure 2-14.

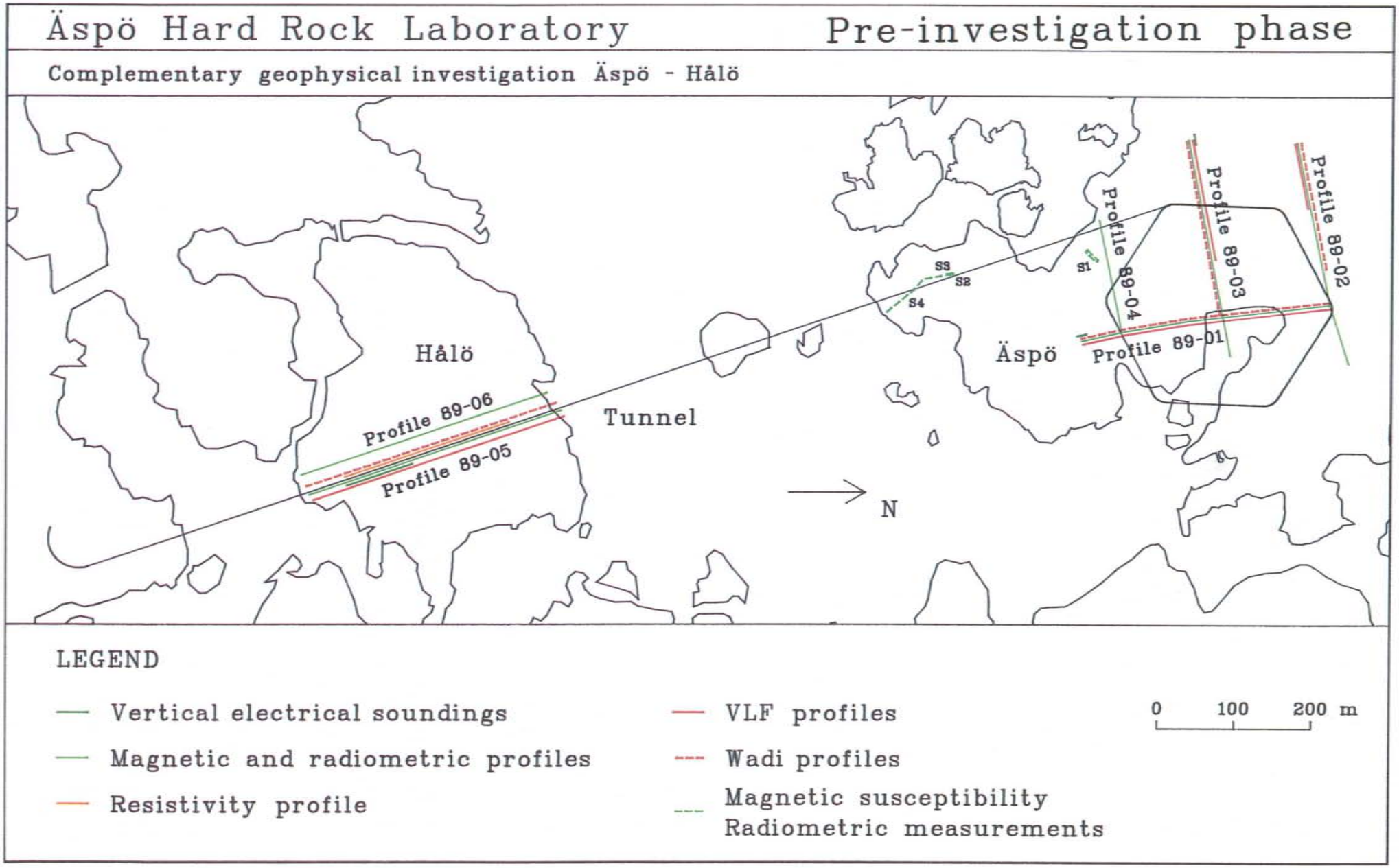

Äspö Hard Rock Laboratory
Pre-investigation phase
Complementary geophysical investigation Äspö - Hålö
Hålö
Äspö
Tunnel
Profile 89-06
Profile 89-05
Profile 89-01
Profile 89-02
Profile 89-03
Profile 89-04
S1
S2
S3
S4
N
LEGEND
Vertical electrical soundings
Magnetic and radiometric profiles
Resistivity profile
VLF profiles
Wadi profiles
Magnetic susceptibility
Radiometric measurements
0 100 200 m

Figure 2-15.

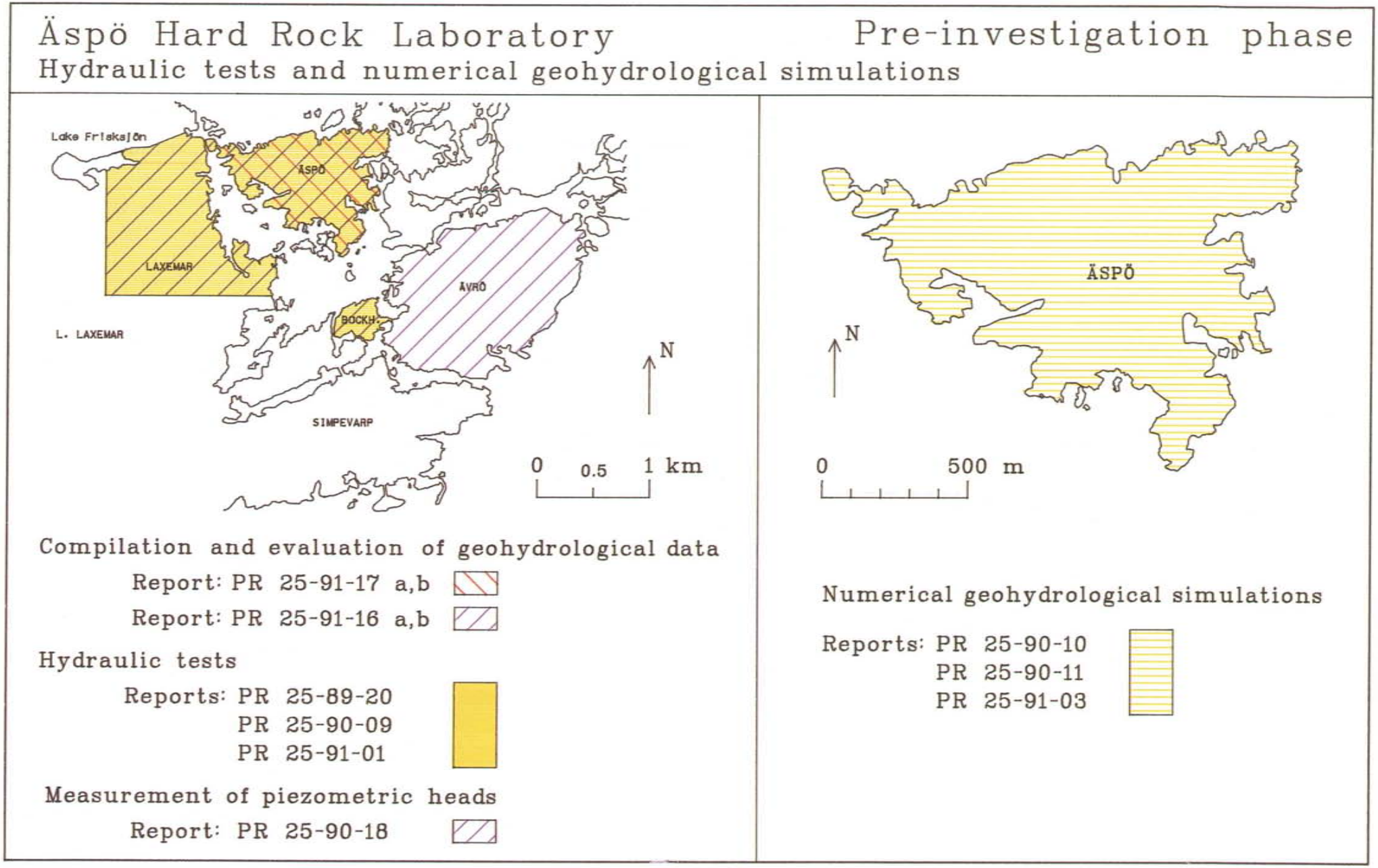

Äspö Hard Rock Laboratory
Pre-investigation phase
Hydraulic tests and numerical geohydrological simulations
Lake Frisksjön
ÄSPÖ
LAXEMAR
ÄVRÖ
BOCKH.
L. LAXEMAR
SIMPEVARP
N
0 0.5 1 km
ÄSPÖ
N
0 500 m
Compilation and evaluation of geohydrological data
Report: PR 25-91-17 a,b
Report: PR 25-91-16 a,b
Hydraulic tests
Reports: PR 25-89-20
PR 25-90-09
PR 25-91-01
Measurement of piezometric heads
Report: PR 25-90-18
Numerical geohydrological simulations
Reports: PR 25-90-10
PR 25-90-11
PR 25-91-03

Figure 2-16.

3. BOREHOLE INVESTIGATIONS

This part of the report comprises a compilation of borehole data and investigations performed in the boreholes. The information is given in CAD-generated illustrations which can be used as a reference guide for more detailed investigations.

Figures 3-1 to 3-4 gives information concerning the location of the percussion and cored boreholes on Äspö - Hålö and Laxemar. An overview of the scope of work performed in the different boreholes are compiled in figures 3-5 and 3-6. The borehole lithologies are illustrated in figures 3-7 to 3-9 for the cored boreholes and figures 3-38 to 3-44 for the percussion boreholes. More detailed information for the cored boreholes concerning the different methods are compiled in figures 3-10 to 3-37.

Äspö Hard Rock Laboratory
Pre-investigation phase

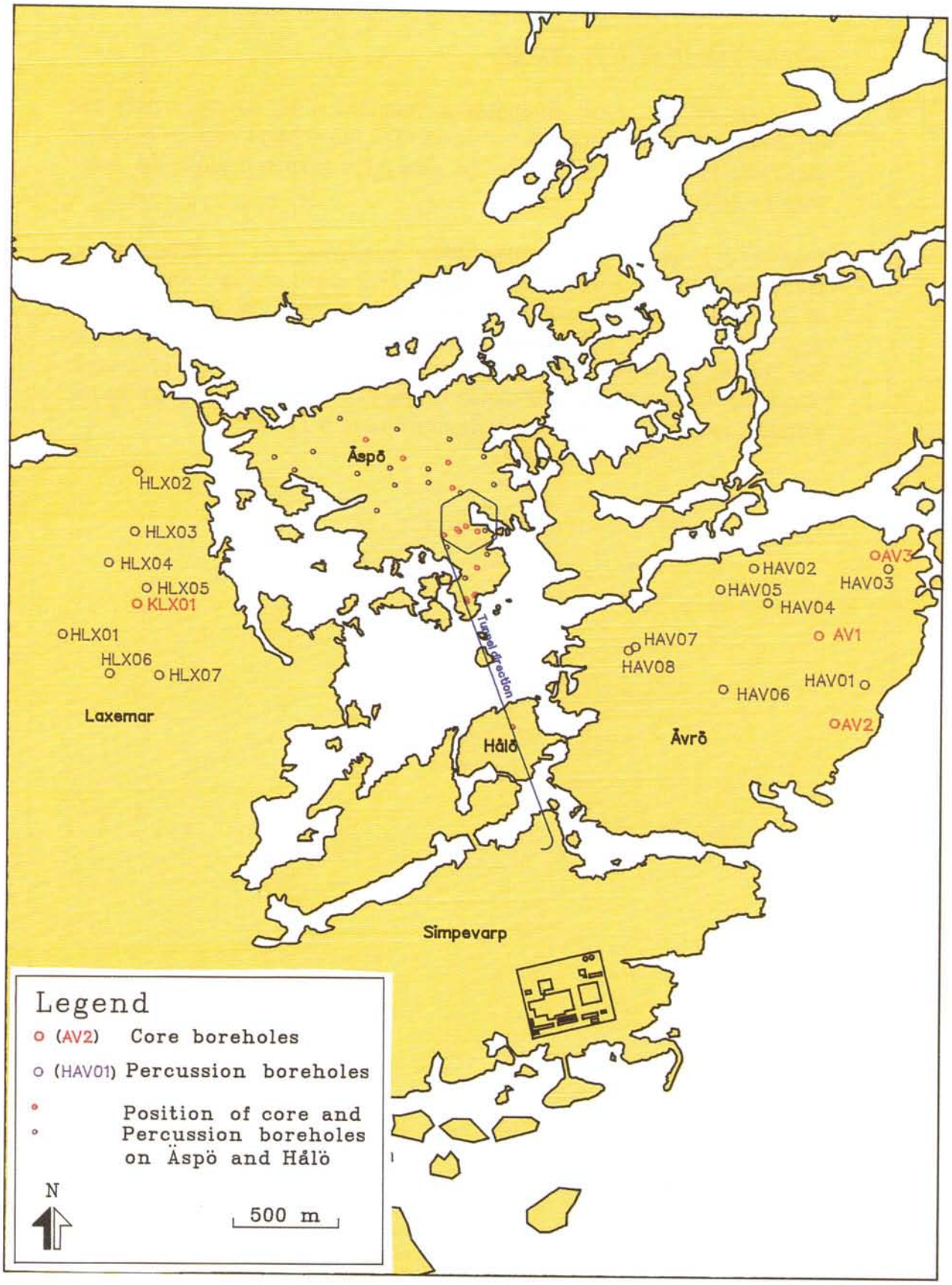


Figure 3-1. Overview of the borehole locations in the pre-investigation area.

Äspö Hard Rock Laboratory
Pre-investigation phase

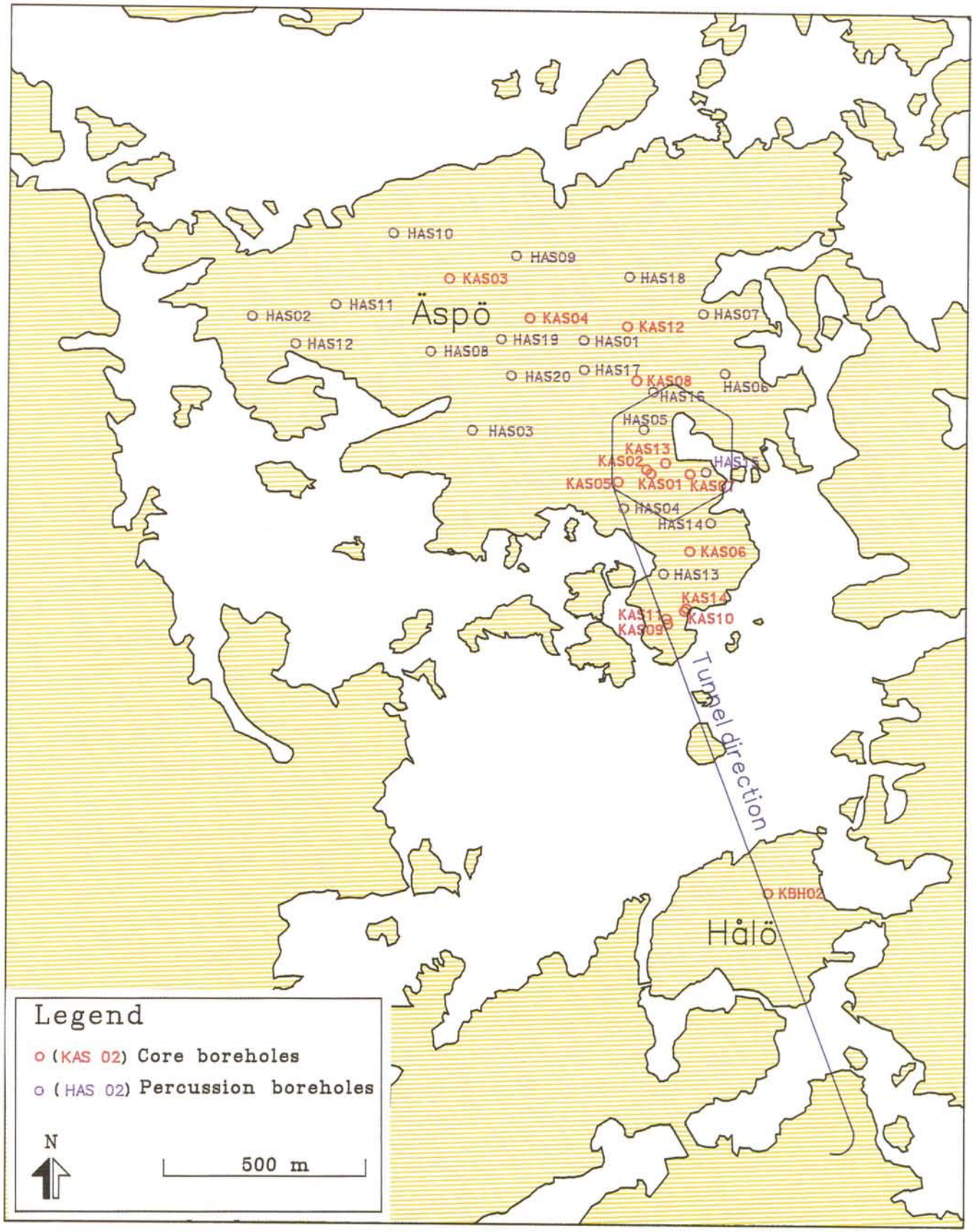


Figure 3-2. Borehole locations in the Äspö-Hålö area.

Äspö Hard Rock Laboratory

Pre-investigation phase

Boreholes on Äspö - Hålö - Ävrö - Laxemar

BOREHOLE	X-COORD.	Y-COORD.	Z-COORD.	LENGTH	DIP	DIR.	FIG.
KAS 02	7250.110	2125.224	7.68	924	85	330	3-10
KAS 03	7758.228	1805.205	8.79	1002	85	330	3-11
KAS 04	7636.826	1955.060	11.66	481	60	135	3-12
KAS 05	7247.974	2059.615	8.68	550	85	150	3-13
KAS 06	7067.749	2175.081	5.16	602	60	355	3-14
KAS 07	7229.662	2215.403	4.58	604	59	205	3-15
KAS 08	7451.052	2150.440	7.66	601	60	135	3-16
KAS 09	6925.190	2091.110	4.08	450	60	169	3-17
KAS 10	6943.950	2133.000	3.34	99	60	135	—
KAS 11	6937.020	2090.710	4.26	249	89	22	3-18
KAS 12	7568.800	2156.600	4.83	380	69	150	3-19
KAS 13	7264.400	2169.000	3.89	406	62	267	3-20
KAS 14	6948.540	2138.800	3.70	212	60	137	3-21
KBH 02	6313.830	2170.590	4.75	706	45	335	3-22
KLX 01	7265.450	596.020	16.81	702*	85	350	3-23
HAS 01	7559.557	2058.460	6.38	100	61	315	3-38
HAS 02	7776.932	1371.199	2.11	93	55	186	-"-
HAS 03	7428.483	1778.998	2.34	100	56	95	-"-
HAS 04	7189.523	2057.348	6.26	200	61	244	3-39
HAS 05	7343.335	2136.569	6.31	100	58	195	-"-
HAS 06	7420.610	2337.806	4.73	100	88	249	-"-
HAS 07	7555.081	2322.802	3.76	100	62	18	3-40
HAS 08	7613.713	1731.070	6.62	125	58	176	-"-
HAS 09	7770.423	1958.065	7.84	125	59	137	-"-
HAS 10	7879.144	1711.000	6.31	125	61	349	3-41
HAS 11	7758.157	1553.960	5.59	125	89	343	-"-
HAS 12	7697.364	1449.506	2.90	125	60	209	-"-
HAS 13	7031.779	2107.332	2.05	100	63	47	3-42
HAS 14	7114.728	2232.402	1.67	100	88	242	-"-
HAS 15	7223.983	2248.484	4.19	120	60	124	-"-
HAS 16	7417.181	2177.848	4.37	120	60	353	3-43
HAS 17	7498.556	2044.464	7.89	120	60	78	-"-
HAS 18	7670.000	2184.400	7.46	150	62	134	3-44
HAS 19	7603.300	1884.700	8.97	150	57	207	-"-
HAS 20	7529.110	1893.650	6.24	150	60	130	-"-

Notes: Coordinates for boreholes on Ävrö are related to the OKG-System (15.5 gon W of N)
Coordinates for boreholes on Äspö, Laxemar and Hålö are related to the local Äspö-System (15.45 gon W of N). All coordinates are related to top of casing.
Dip and Dir are related to casing orientation.

KAS 02 Cored boreholes

HAS 12 Percussion boreholes

* 1990 deepened to 1078 m

Figure 3-3. Borehole data KAS 02-14, KBH 02, KLX 01 and HAS 01-20.

Äspö Hard Rock Laboratory

Pre-investigation phase

Boreholes on Äspö - Hålö - Ävrö - Laxemar

BOREHOLE	X-COORD.	Y-COORD.	Z-COORD.	LENGTH	DIP	DIR.
AV 01	6367.257	1553.084	13.81	248	90	—
AV 02	6366.849	1553.144	7.54	744	90	—
AV 03	6367.625	1553.355	8.21	97	90	—
HAV 01	6367.022	1553.287	9.27	175	88	322
HAV 02	6367.576	1552.789	6.08	163	90	125
HAV 03	6367.557	1553.412	8.65	134	88	148
HAV 04	6367.417	1552.849	7.53	100	60	168
HAV 05	6367.482	1552.631	6.83	100	55	179
HAV 06	6367.018	1552.633	11.93	100	60	178
HAV 07	6367.227	1552.229	3.68	100	56	54
HAV 08	6367.209	1552.197	6.98	63	62	6
HLX 01	6367.353	1549.569	8.50	100	59	175
HLX 02	6368.095	1549.938	8.61	130	57	327
HLX 03	6367.821	1549.919	10.43	100	62	185
HLX 04	6367.680	1549.793	10.40	120	64	301
HLX 05	6367.559	1549.967	15.55	100	58	175
HLX 06	6367.165	1549.785	15.48	100	60	178
HLX 07	6367.152	1550.015	8.61	100	59	47

Notes: Coordinates for boreholes on Ävrö are related to the OKG-System (15.5 gon W of N)
Coordinates for boreholes on Äspö, Laxemar and Hålö are related to the local Äspö-System (15.45 gon W of N). All coordinates are related to top of casing.
Dip and Dir are related to casing orientation.

AV 02 Cored boreholes

HAv 08 Percussion boreholes

Figure 3-4. Borehole data AV 01-03, HAV 01-08 and HLX 01-07.

Äspö Hard Rock Laboratory

Pre-investigation phase

Borehole investigations

	CORED BOREHOLES KAS02-KAS14													KBH 02	KLX 01
	02	03	04	05	06	07	08	09	10	11	12	13	14		
LENGTH (M)/DIP	924/85	1002/85	481/60	550/85	602/60	604/59	601/60	450/60	99/60	249/89	380/69	406/62	212/60	706/45	702/85
CORE LOGGING															
Lithology	●	●	●	●	●	●	●	●		●	●	●	●	●	●
Thin section analyses	●	●	●	●	●	●	●	●		●	●	●		●	●
Chemical rock analyses	●	●	●											●	●
Fracture mapping + RQD	●	●	●	●	●	●	●	●		●	●	●	●	●	●
Fracture mineral analyses	●	●	●	●	●	●	●								●
TV-orientation/Televiewer*	●	●	●	●*	●*										
PETROPHYSICS															
Density + Porosity	●														●
Magn. suscep. + Remanence	●														●
Resistivity + I P	●														●
U,Th,K	●														
GEOPHYSICAL LOGGING															
Borehole deviation	●	●	●	●	●	●	●	●		●	●	●	●		●
Caliper + Magnetic suscept.	●	●	●	●	●	●	●	●		●	●	●	●		●
Sonic	●	●	●	●	●	●	●	●		●	●	●	●		●
Natural gamma	●	●	●	●	●	●	●	●		●	●	●	●		●
Density + Neutron				●	●	●	●	●		●	●	●	●		
Resistivity+Spontaneous potent.	●*	●*	●*	●	●	●	●	●		●	●	●	●		●
Temperature	●	●	●	●	●	●	●	●		●	●	●	●		●
Borehole fluid resistivity	●	●	●	●	●	●	●	●		●	●	●	●		●
Radar	●	●	●	●	●	●	●	●		●	●	●	●		●
ROCK STRESS MEASUREMENT															
Hydraulic fracturing	●	●													
Overcoring				●											
Lab. tests	●	●													
GEOHYDROLOGY															
Airlift test, intervals	●	●	●	●	●	●	●	●		●	●	●	●	●	●
Injection test, 3m interval	●	●	●	●	●	●	●								●
Injection test, 30m interval	●	●													●
Spinner(flow meter logging)	●	●	●		●	●	●	●		●	●	●	●		
Pumping test	●	●	●	●	●	●	●	●					●		●
Pumping interference test	●	●			●	●		●		●	●	●	●	●	
Dilution test, intervals	●	●	●	●	●	●	●	●		●	●	●	●	●	
Observation, packer settings	●	●	●	●	●	●	●	●		●	●	●	●	●	
Fluid conductivity	●	●	●	●	●	●	●	●		●	●	●	●	●	
Circulation sections	●	●	●	●	●	●	●	●		●	●	●	●	●	
GROUNDWATER CHEMISTRY															
Complete chemical character.	●	●	●												●
Sampling during pumping test	●	●			●										
Sampling during drilling				●	●	●	●	●		●	●	●	●	●	●
Fracture mineral statistics	●	●	●	●	●	●	●								●
Fracture mineral chemistry	●				●										●

Figure 3-5. Borehole investigations in cored boreholes.

Äspö Hard Rock Laboratory

Pre-investigation phase

Borehole investigations

	PERCUSSION BOREHOLES HAS01-HAS20																			
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
LENGTH (M)/DIP	100/61	93/55	100/56	200/61	100/58	100/88	100/62	125/58	125/59	125/61	125/89	125/60	100/63	100/88	120/60	120/60	120/60	150/62	150/57	150/60
DRILLING DATA																				
Drill cutting analyses	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●
Thin section analyses																				
Drilling rate	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Fracture identification	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
GEOPHYSICAL LOGGING																				
Borehole deviation	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Density				●									●	●				●	●	●
Magnetic suscept.	●	●	●	●	●	●	●	●	●	●	●	●	●	●				●	●	●
Sonic				●									●	●				●	●	●
Natural gamma	●	●	●	●	●	●	●	●	●	●	●	●	●	●				●	●	●
Resistivity	●	●	●	●	●	●	●	●	●	●	●	●	●	●				●	●	●
Temperature	●	●	●	●	●	●	●	●	●	●	●	●	●	●				●	●	●
Borehole fluid resistivity	●	●	●	●	●	●	●	●	●	●	●	●	●	●				●	●	●
Radar		●	●																	
GEOHYDROLOGY																				
Airlift test, intervals	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Injection test, 3m interval																				
Injection test, 30m interval																				
Spinner (flow meter logging)																				
Pumping test	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Pumping interference test													●							●
Dilution, test intervals																				
Observation packer settings																				
Fluid conductivity																				
Circulation sections																				
GROUNDWATER CHEMISTRY																				
Complete chemical character.																				
Sampling during pumping test																				
Sampling during drilling		●	●		●	●	●													
Fracture mineral statistics																				
Fracture mineral chemistry																				

Figure 3-6. Borehole investigations in percussion boreholes.

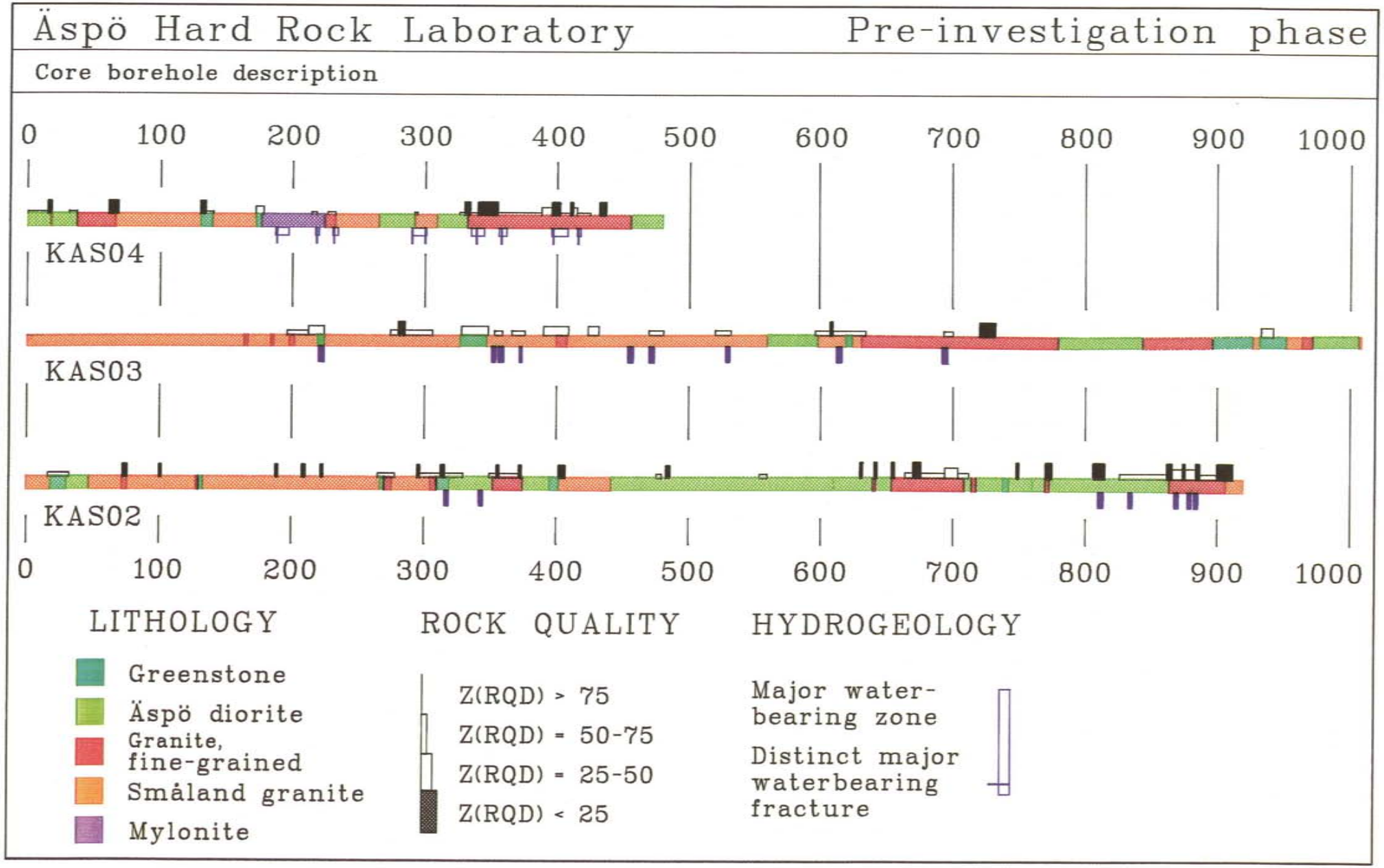


Figure 3-7. Core boreholes KAS 02-04.

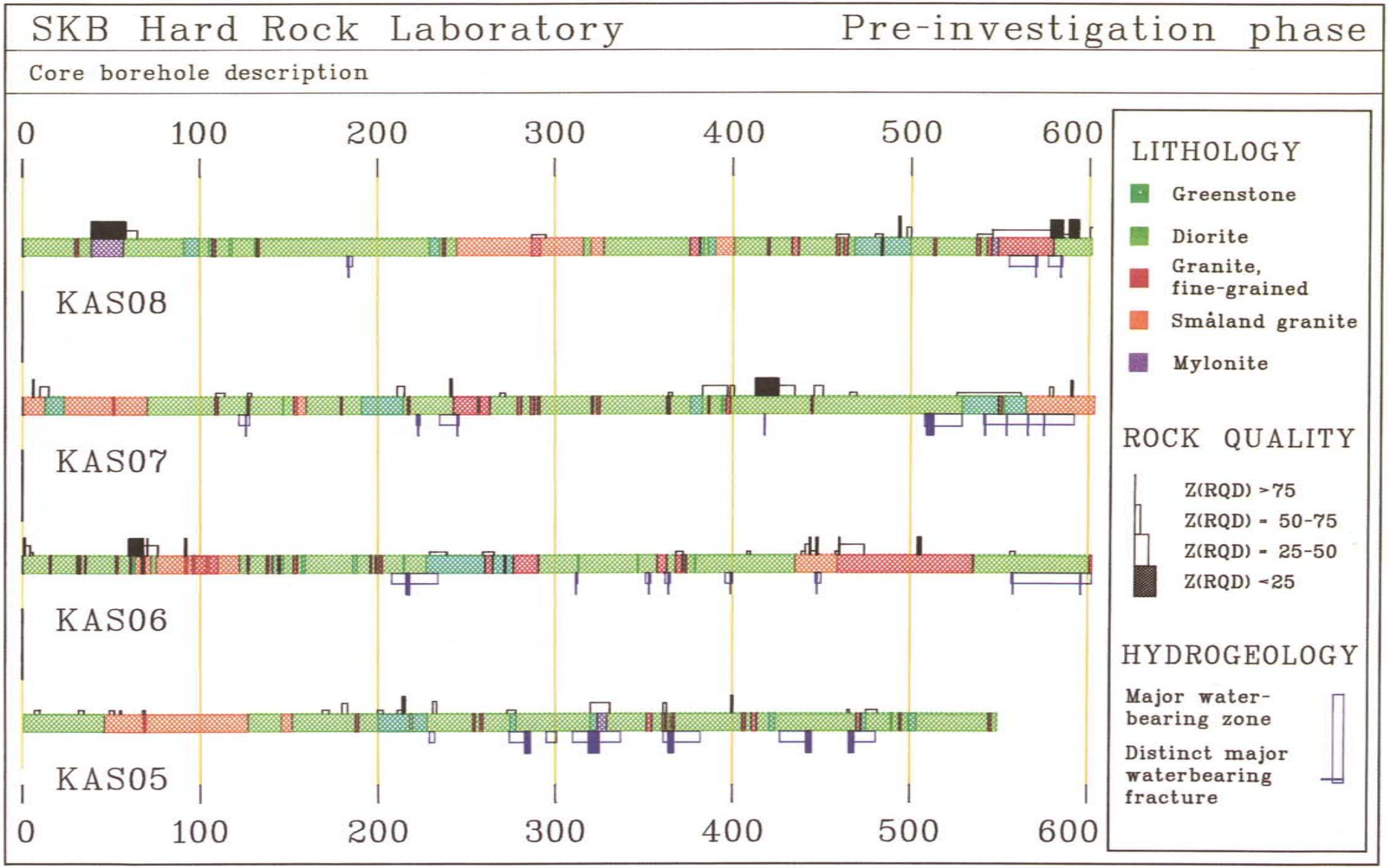


Figure 3-8. Core boreholes KAS 05-08.

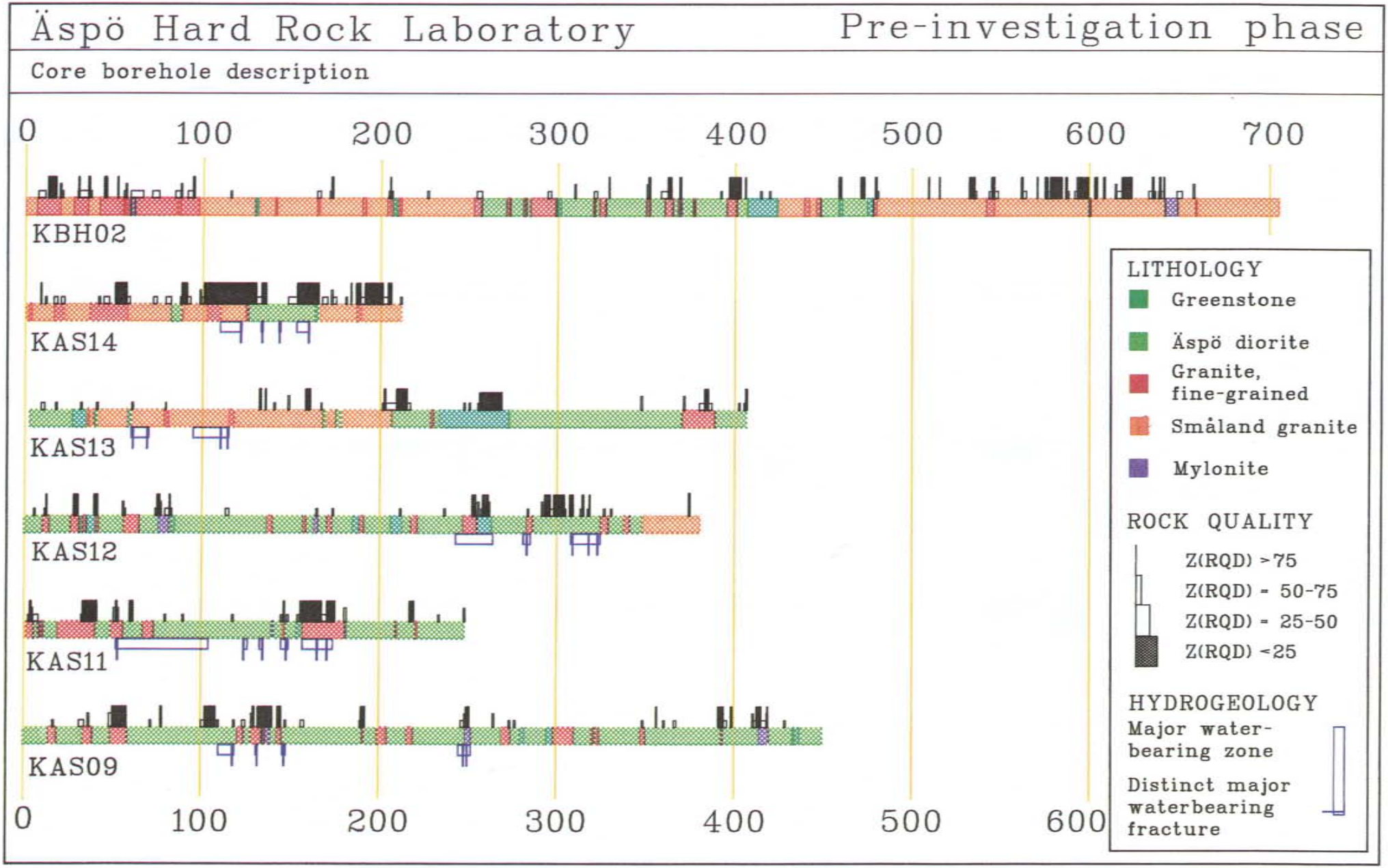


Figure 3-9. Core boreholes KAS 09, KAS 11-14, KBH 02.

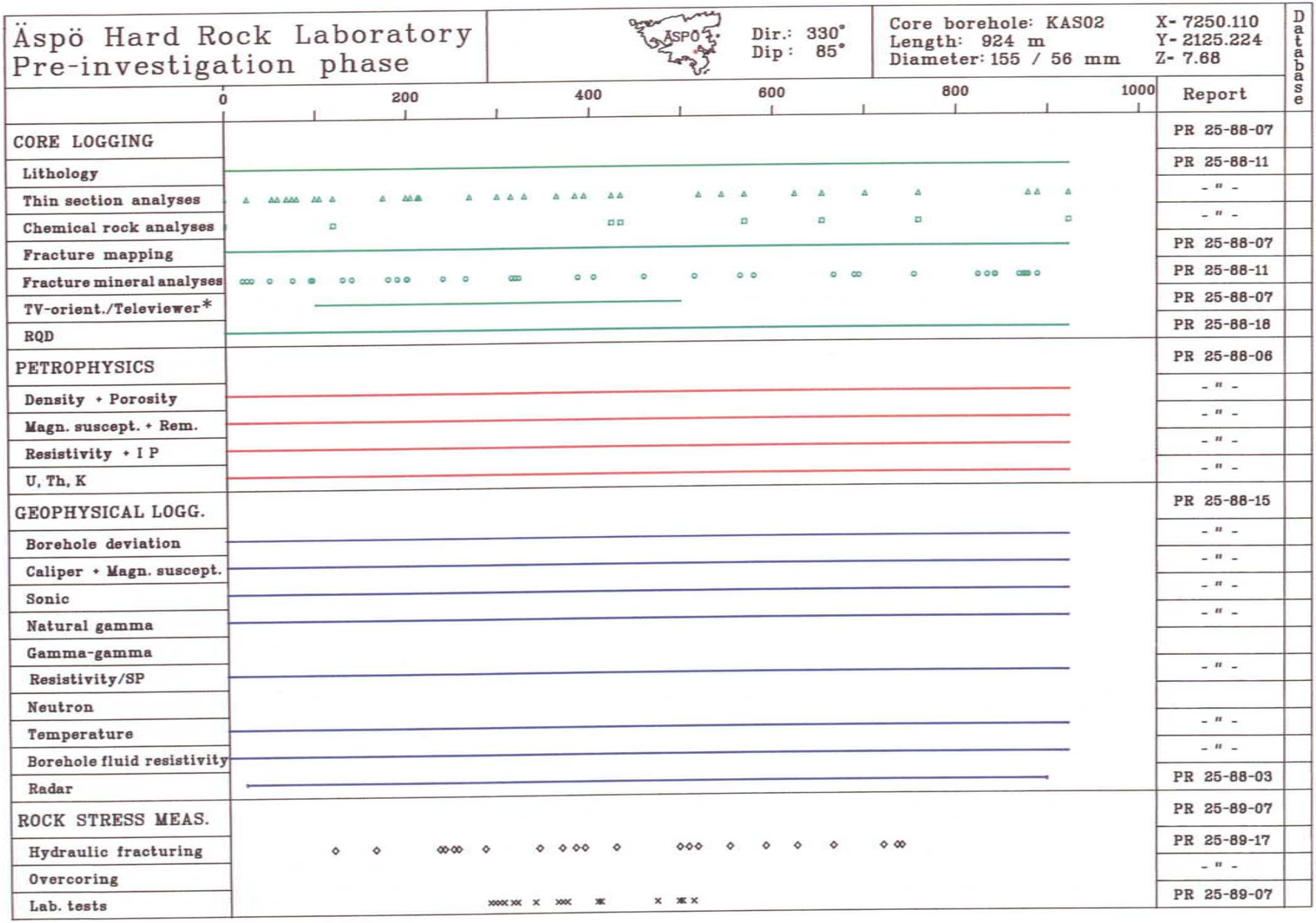


Figure 3-10. KAS 02. Borehole data. Geology.

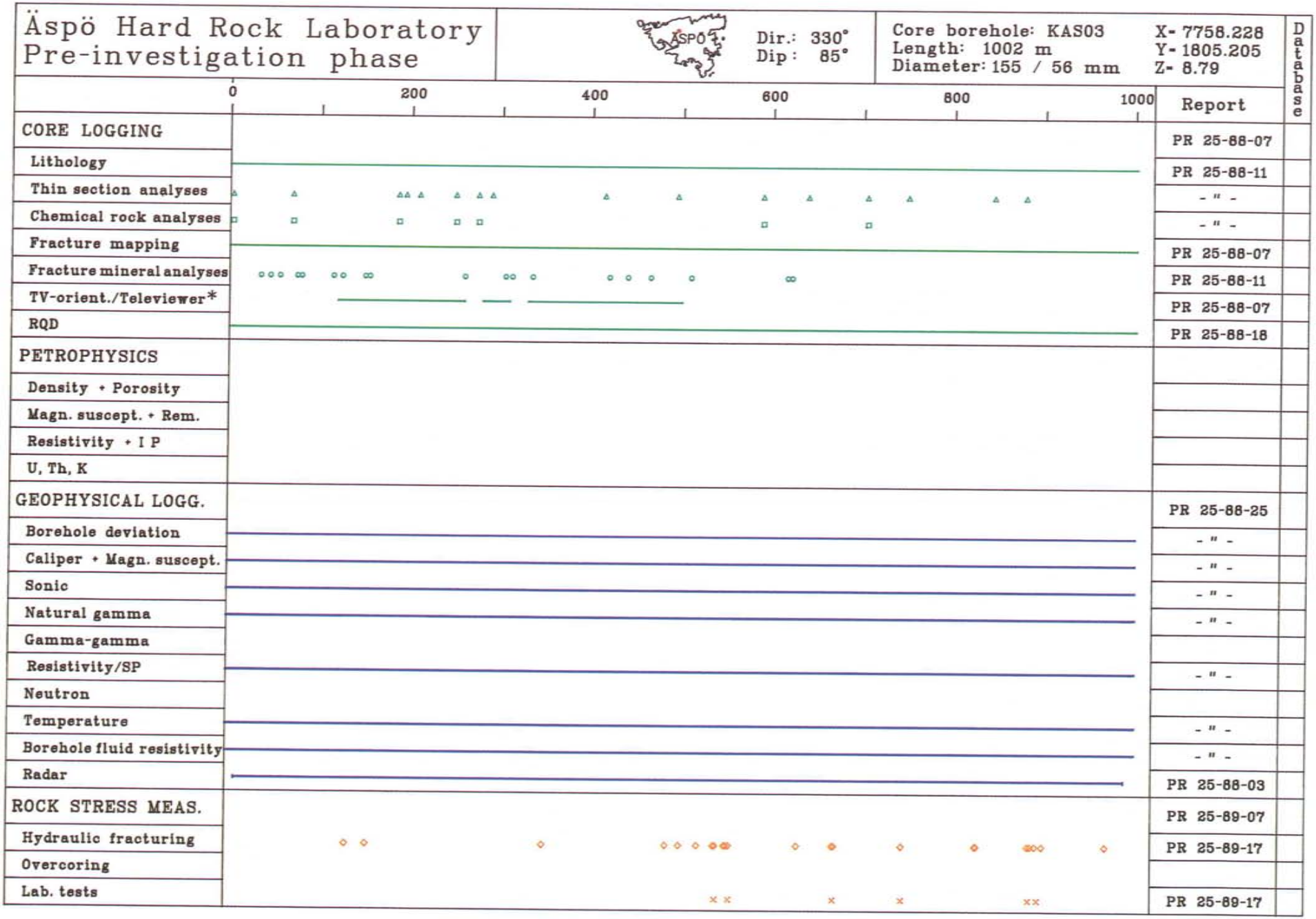


Figure 3-11. KAS 03. Borehole data. Geology.

Figure 3-12. KAS 04. Borehole data. Geology.

Figure 3-13. KAS 05. Borehole data. Geology.

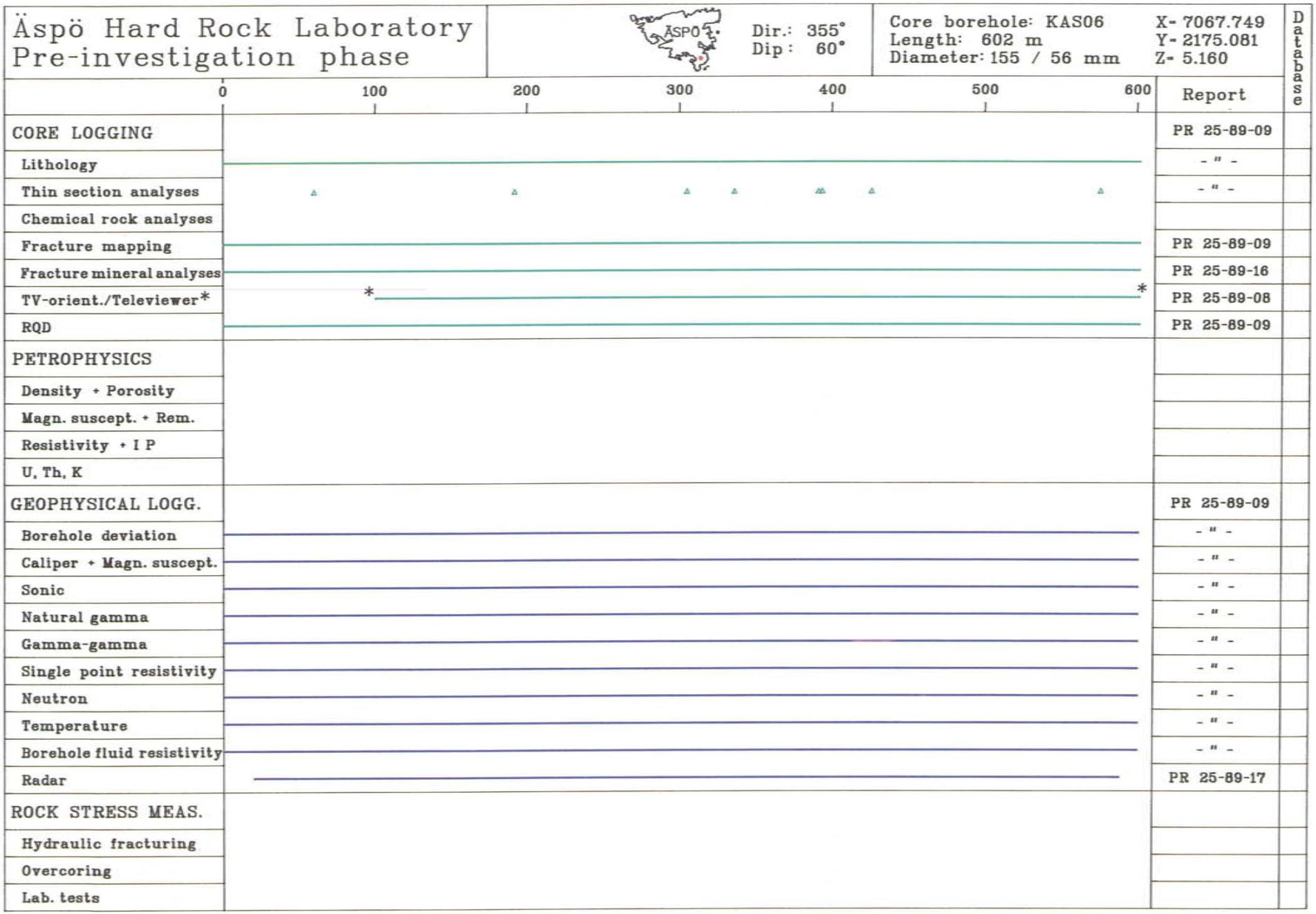


Figure 3-14. KAS 06. Borehole data. Geology.

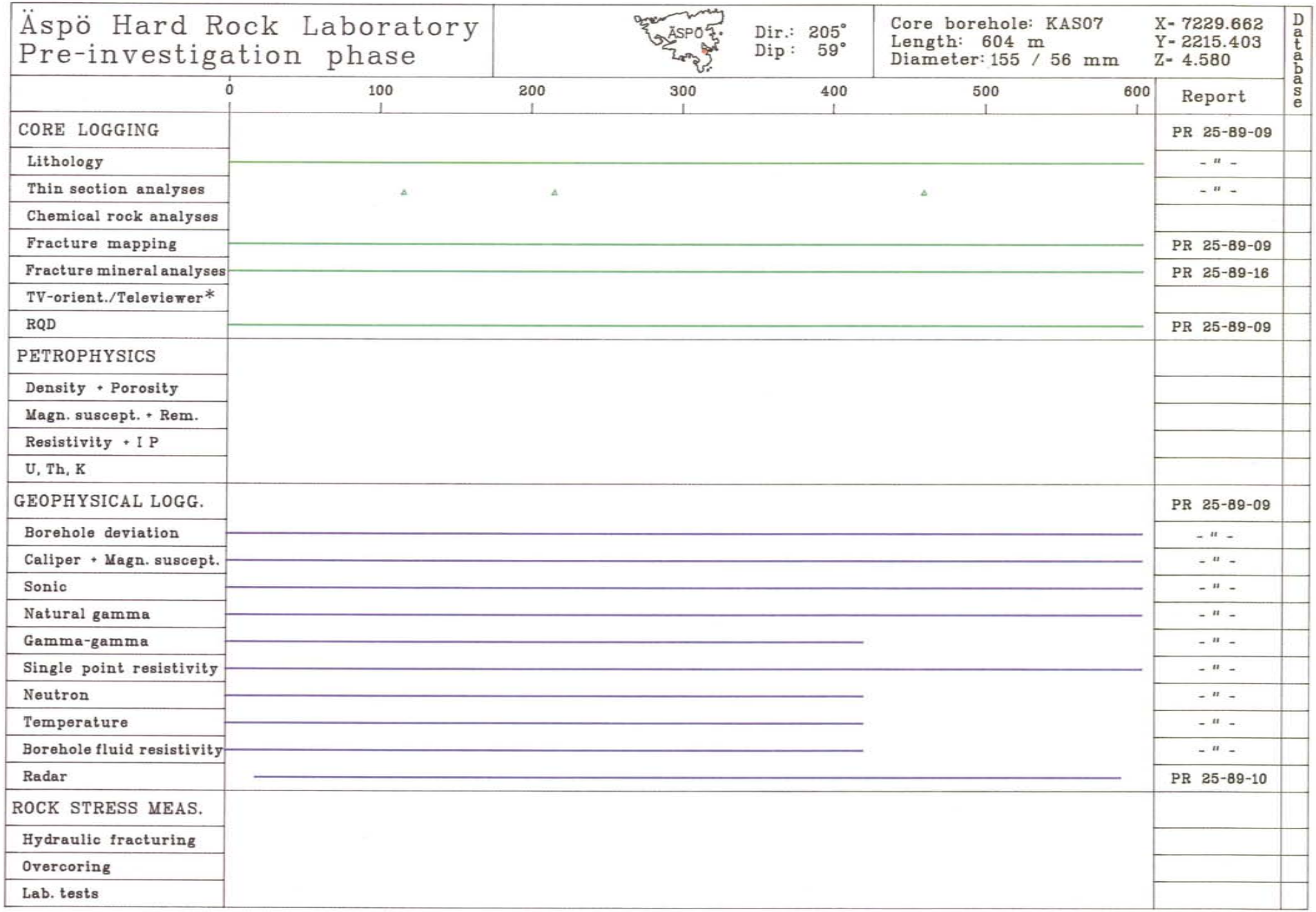


Figure 3-15. KAS 07. Borehole data. Geology.

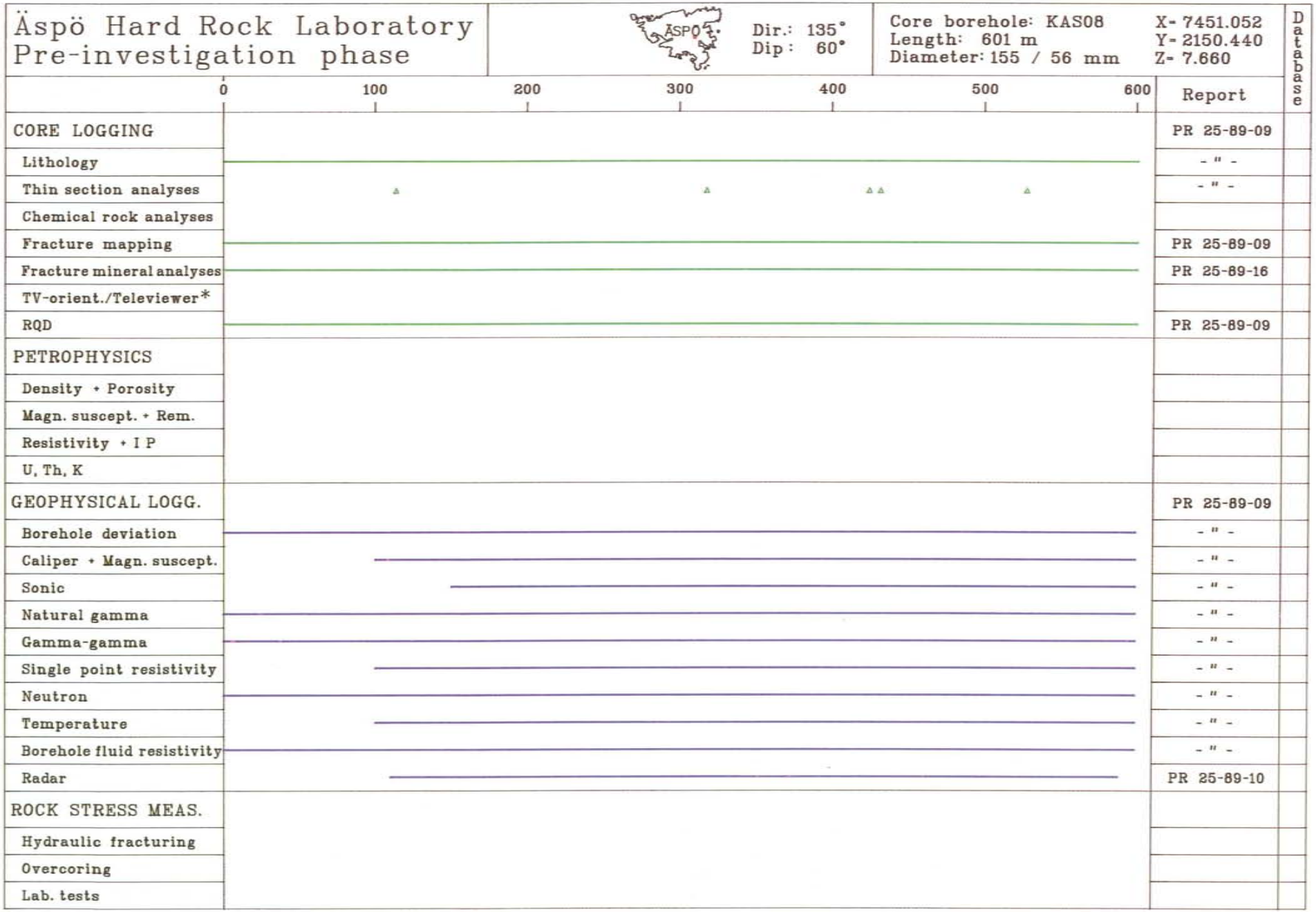


Figure 3-16. KAS 08. Borehole data. Geology.

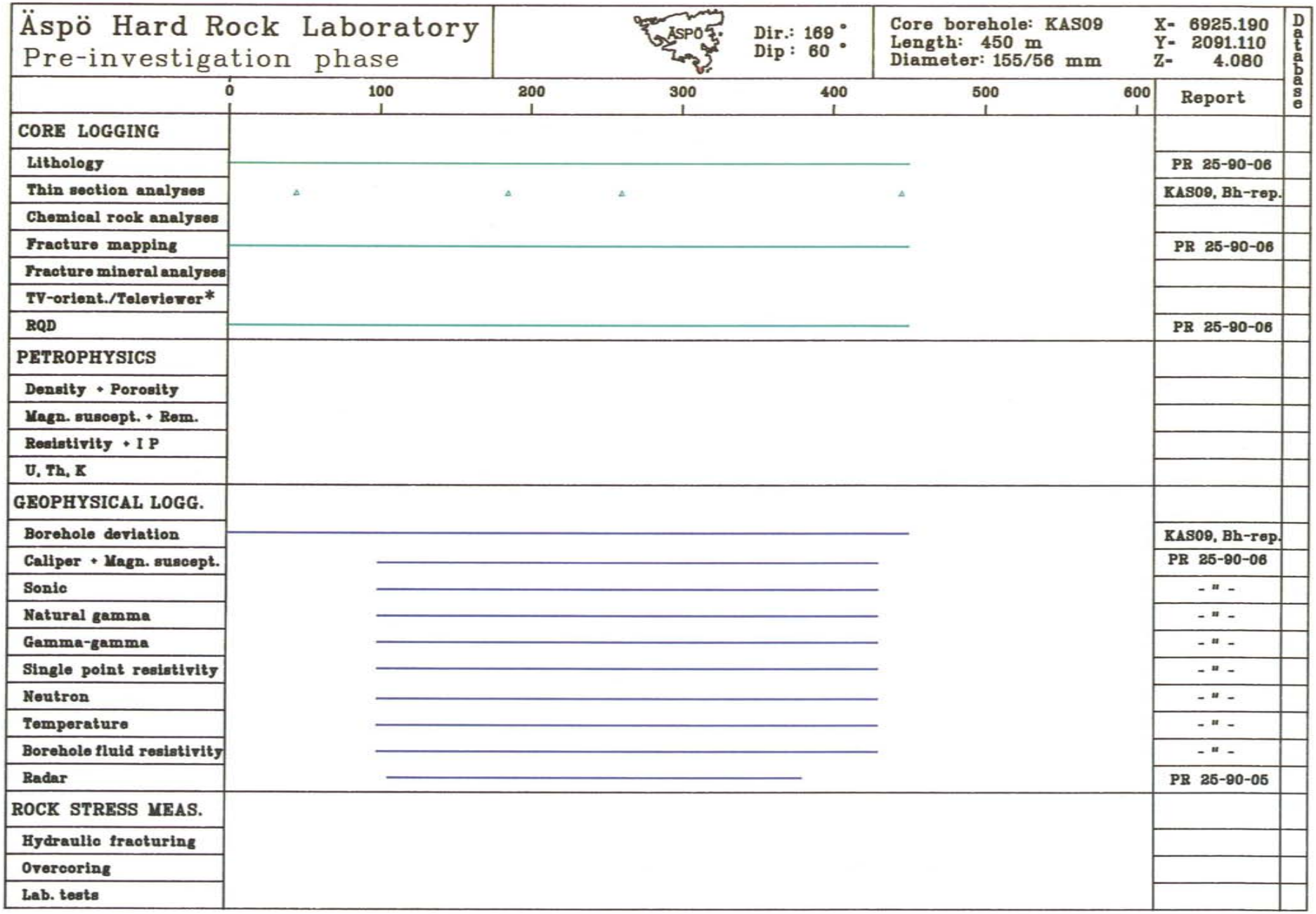


Figure 3-17. KAS 09. Borehole data. Geology.

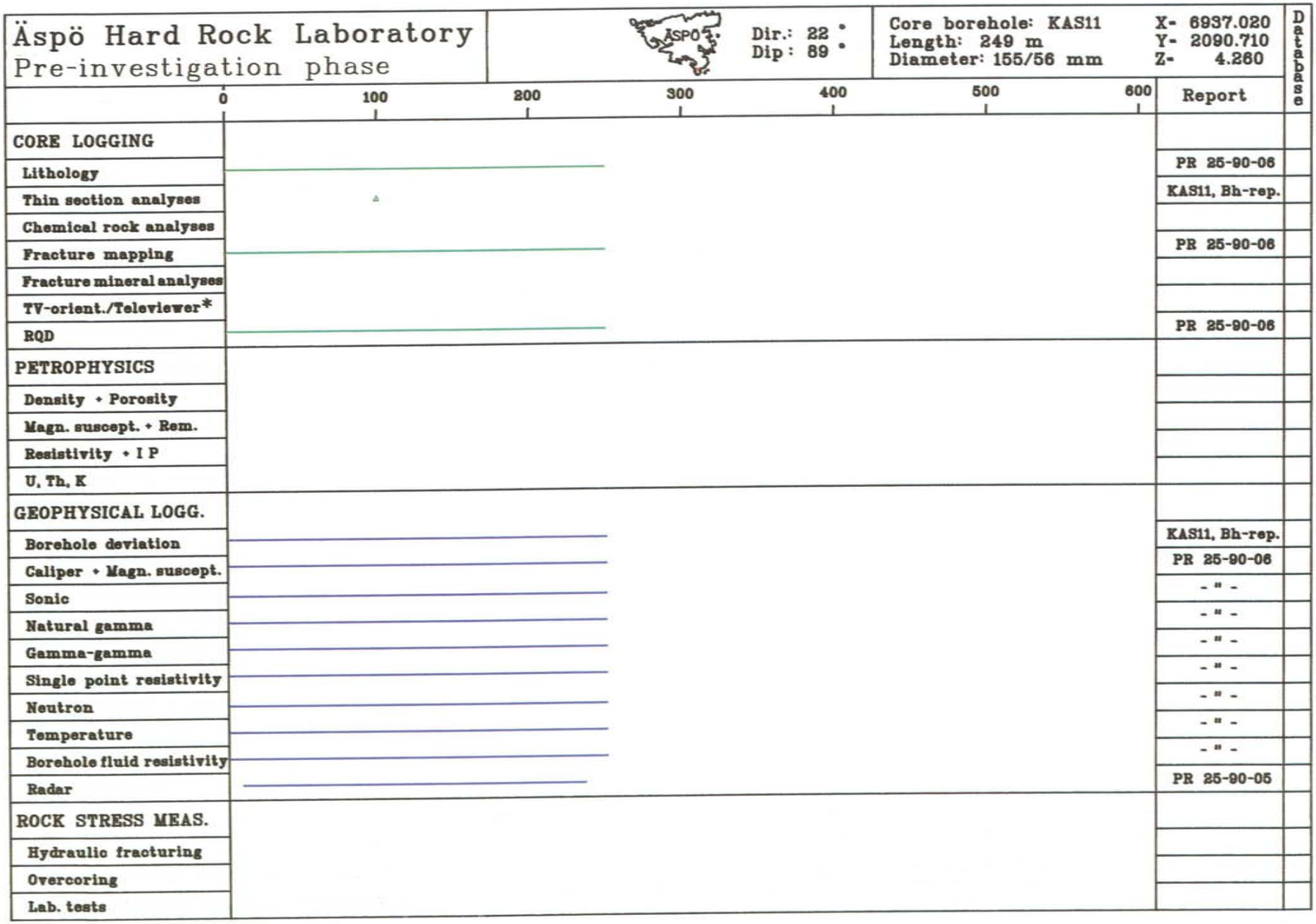


Figure 3-18. KAS 11. Borehole data. Geology.

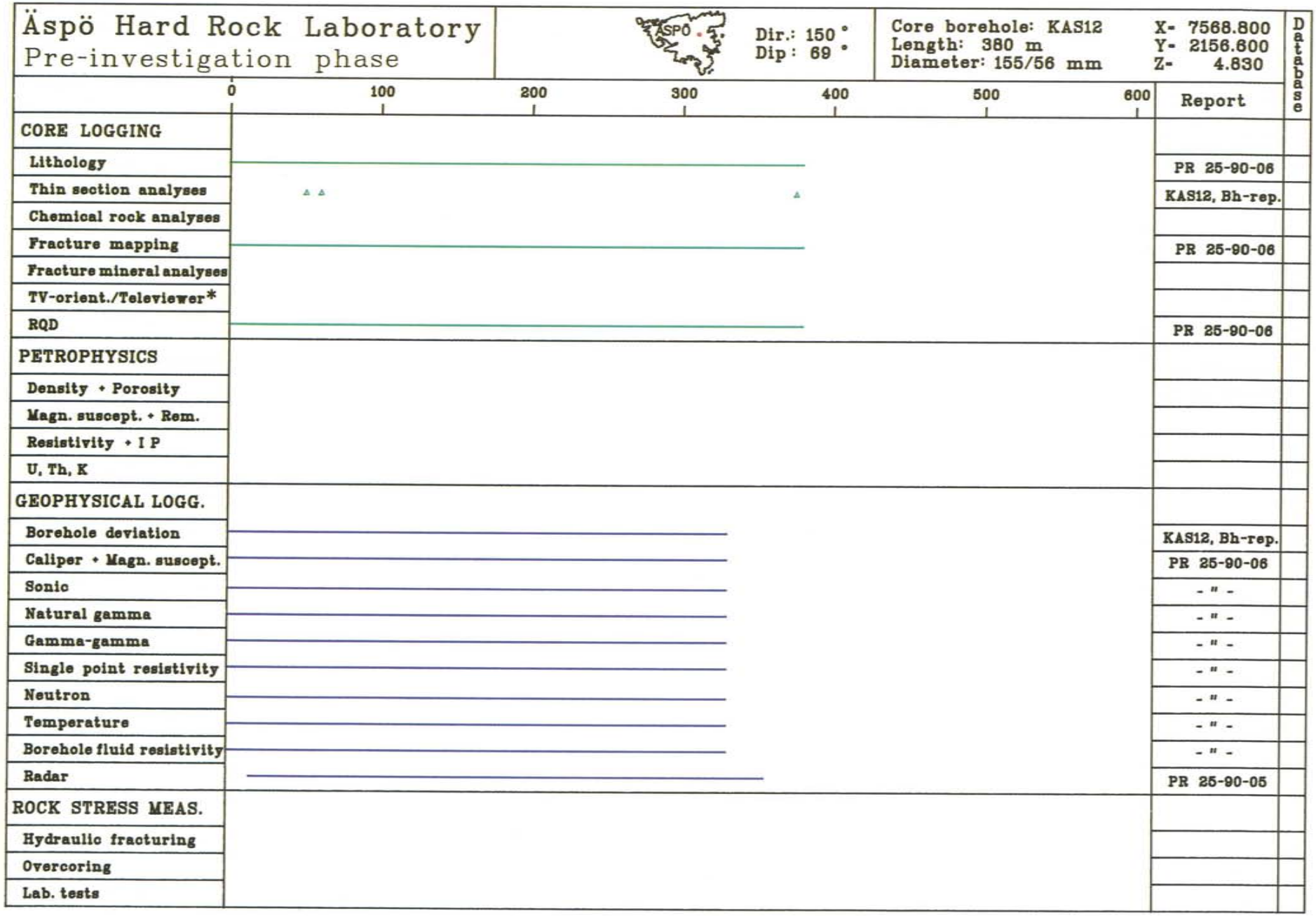


Figure 3-19. KAS 12. Borehole data. Geology.

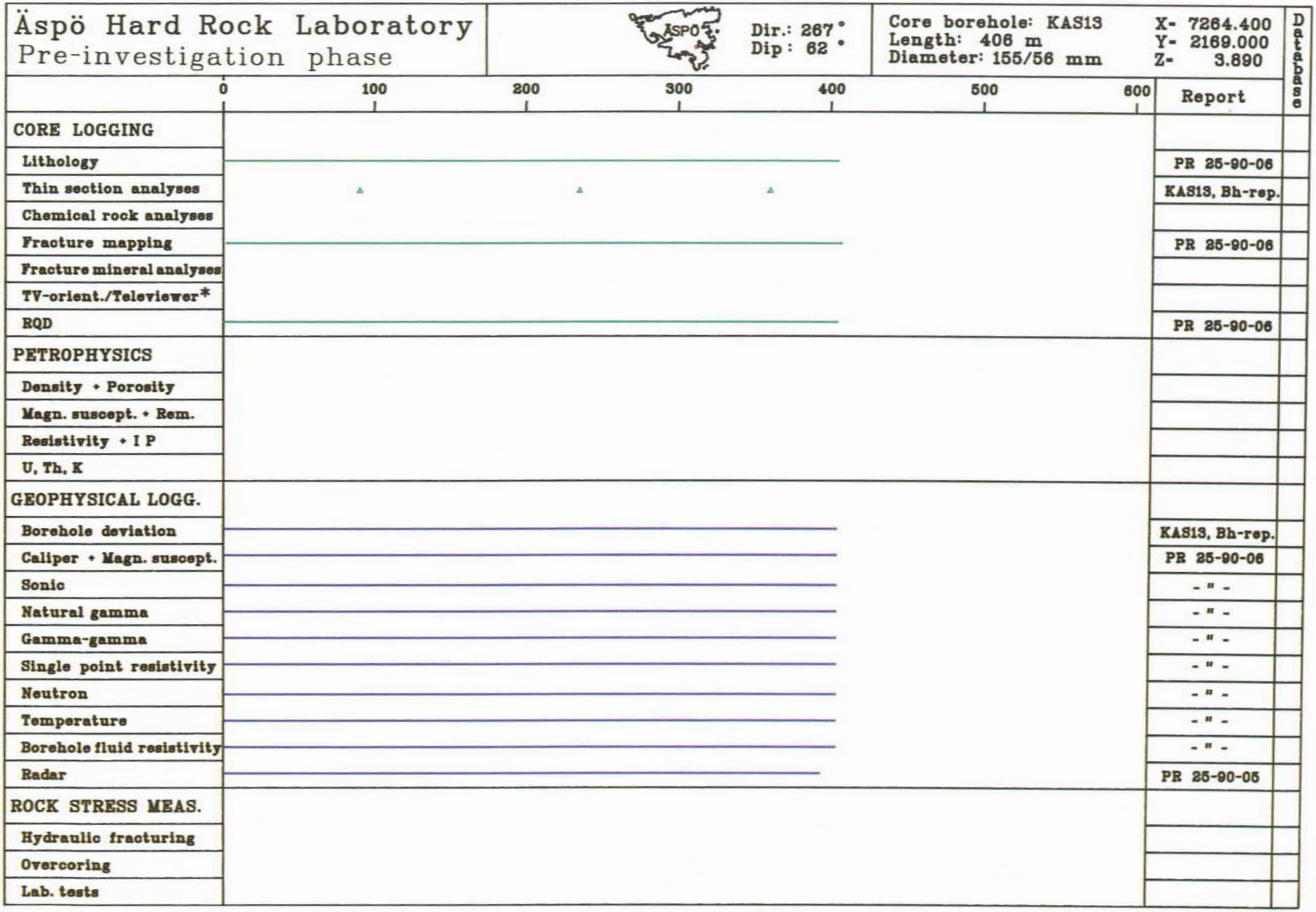


Figure 3-20. KAS 13. Borehole data. Geology.

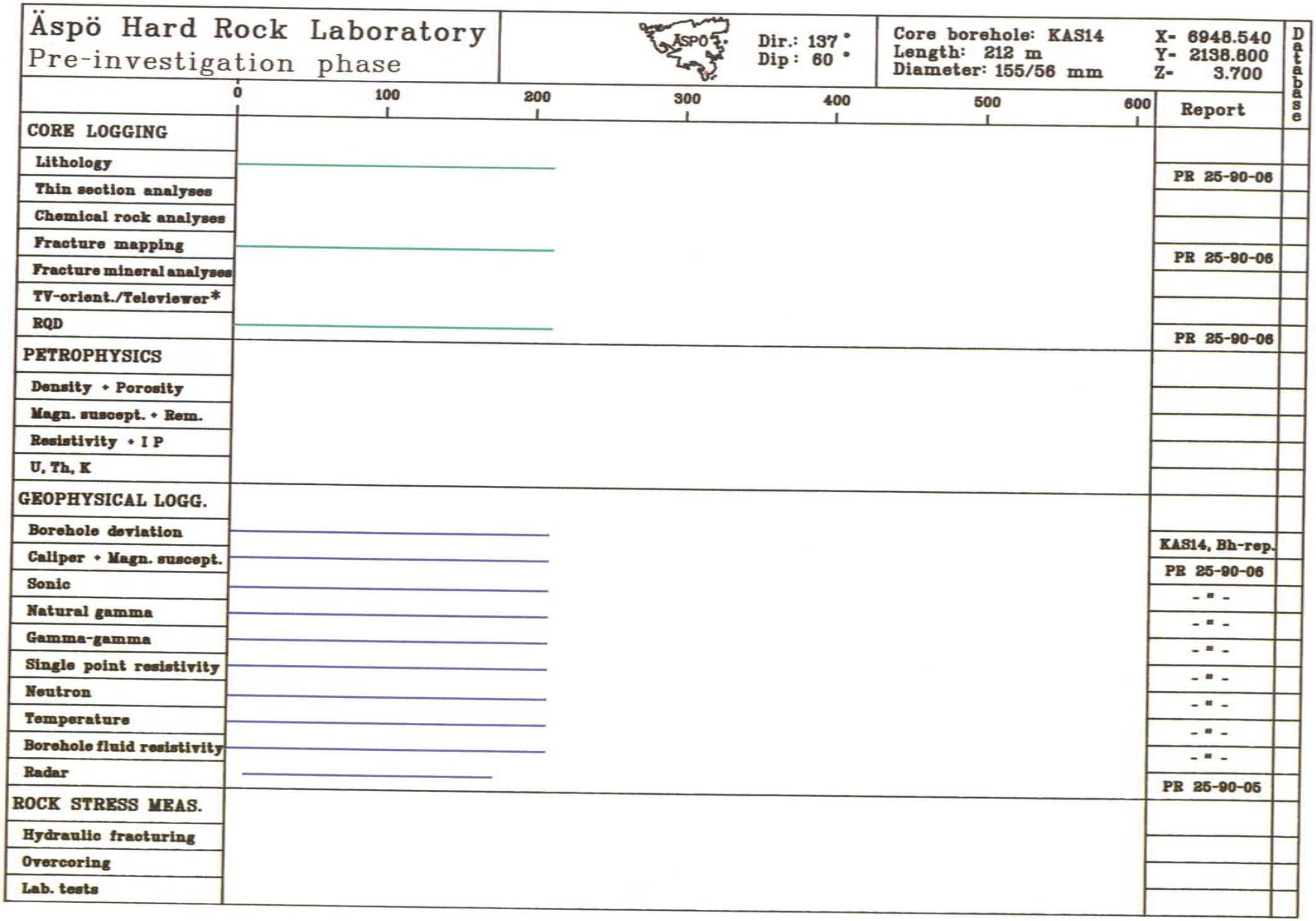


Figure 3-21. KAS 14. Borehole data. Geology.

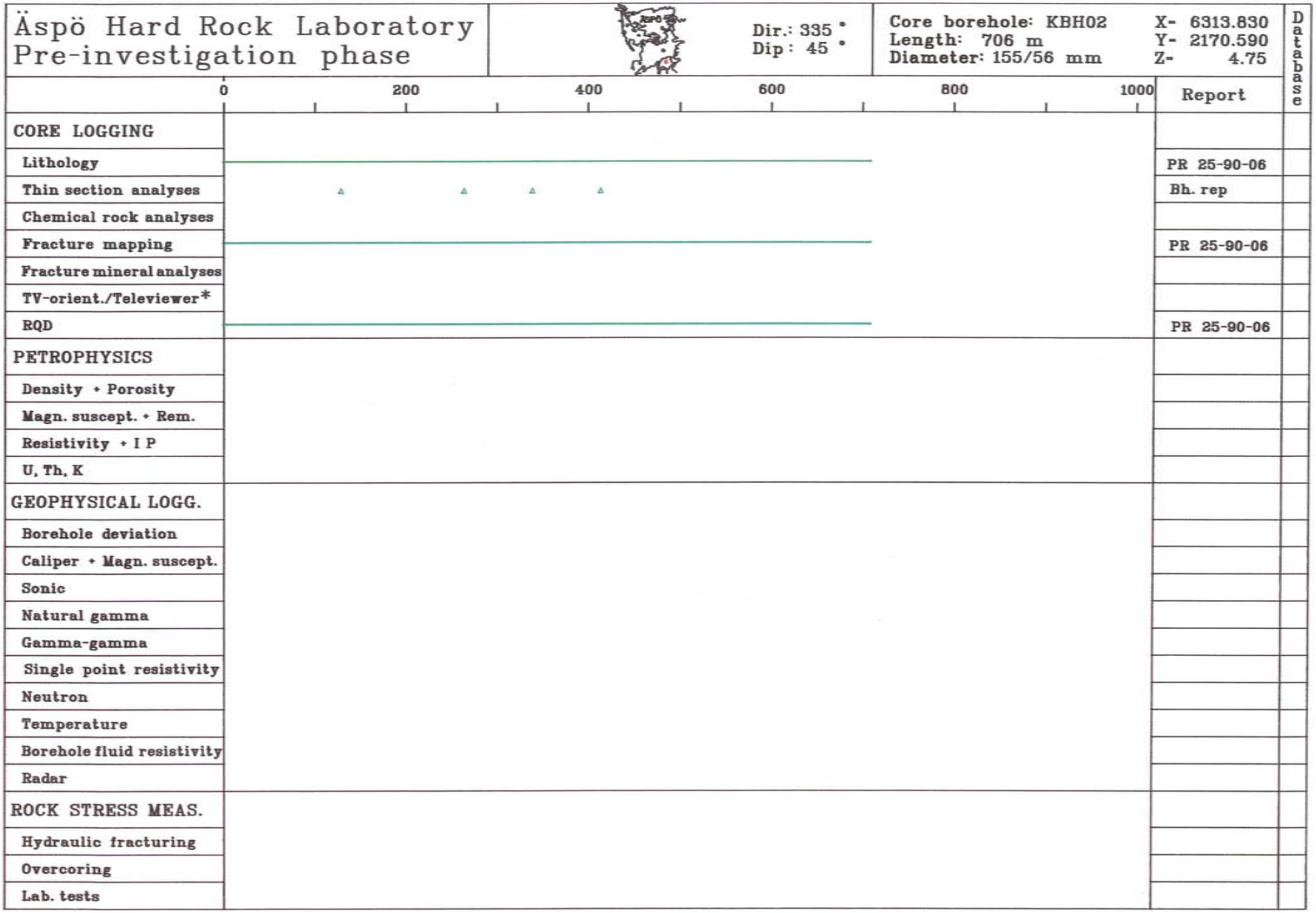


Figure 3-22. KBH 02. Borehole data. Geology.

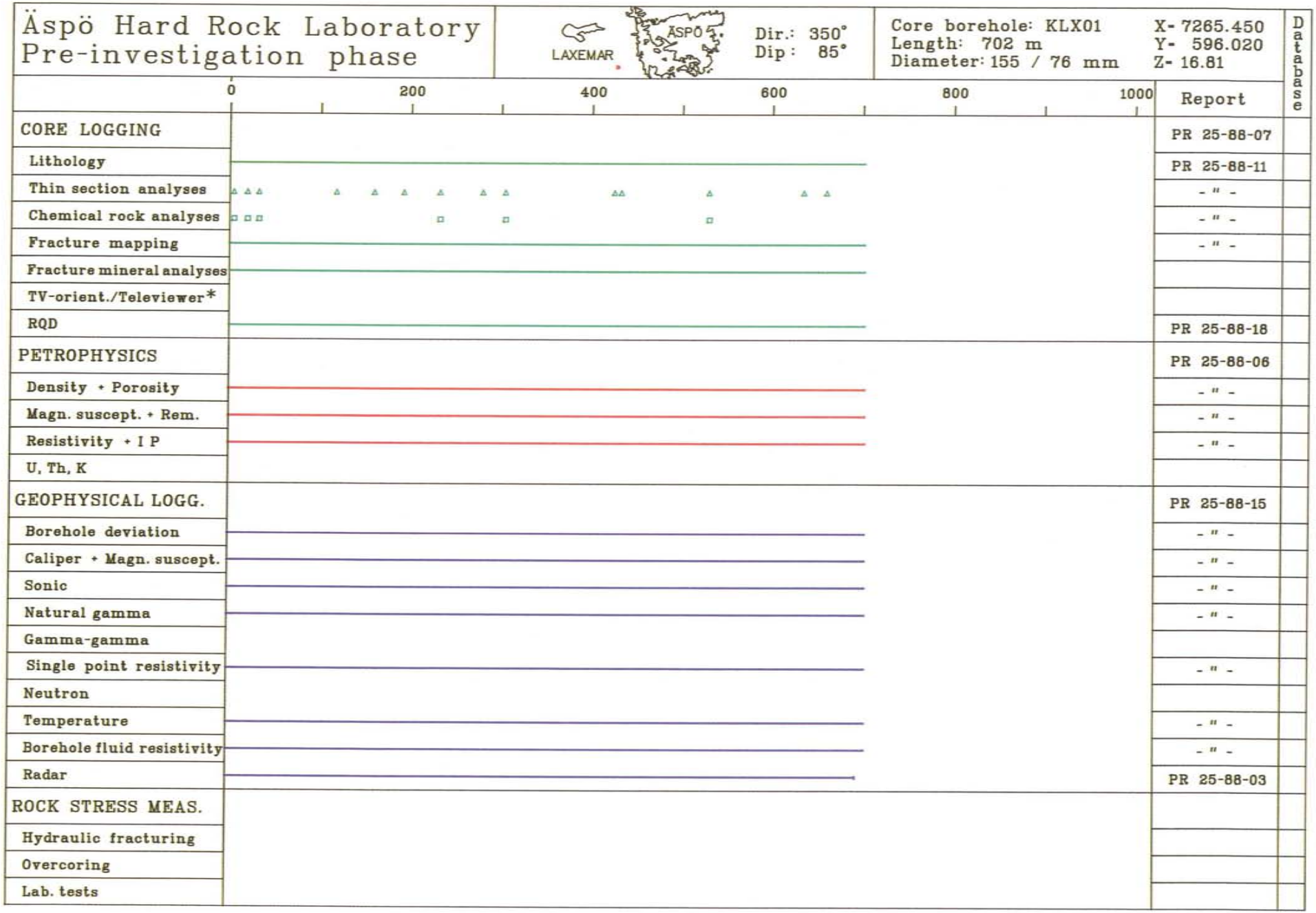


Figure 3-23. KLX 01. Borehole data. Geology.

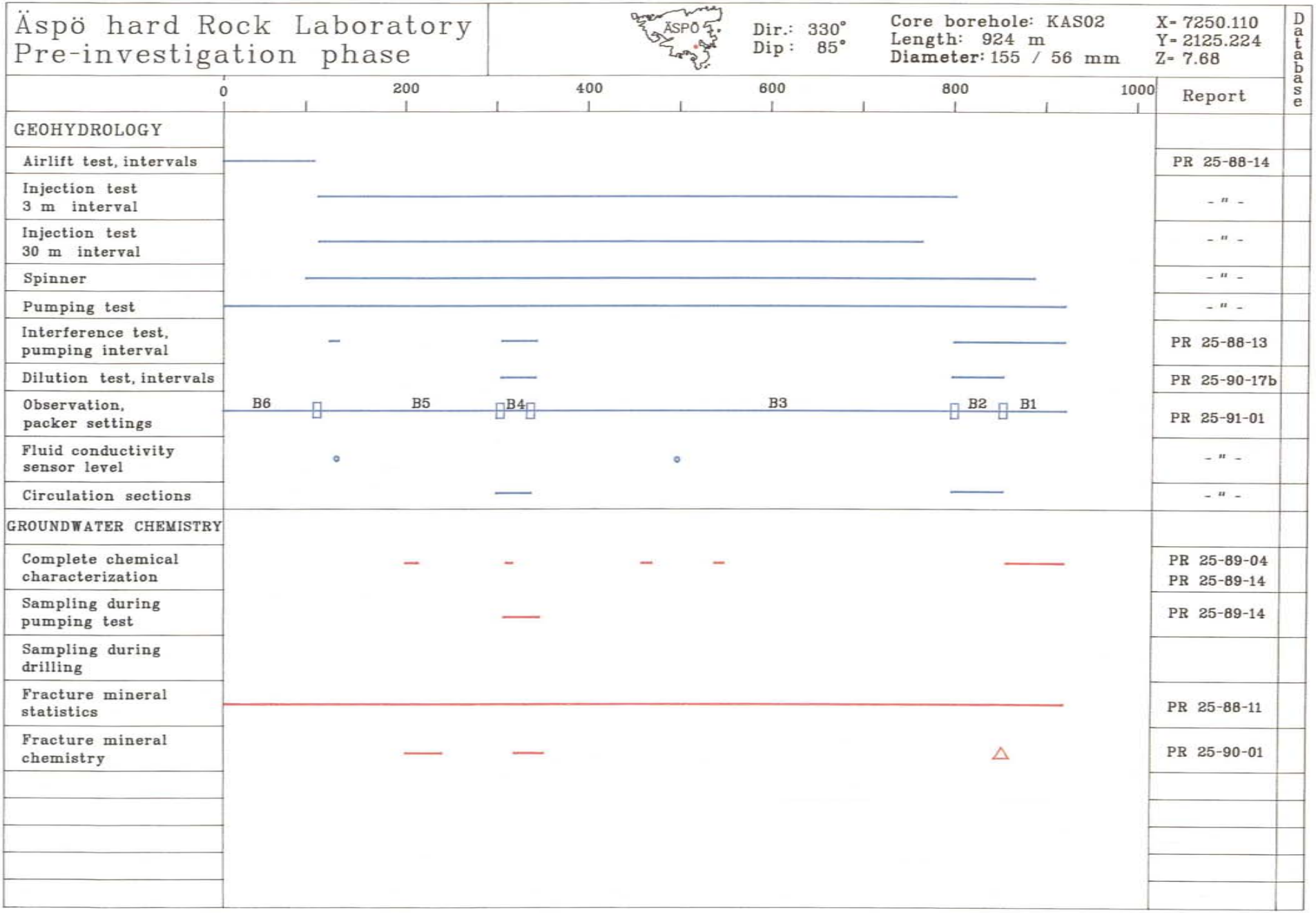


Figure 3-24. KAS 02. Borehole data. Geohydrology and groundwater chemistry.

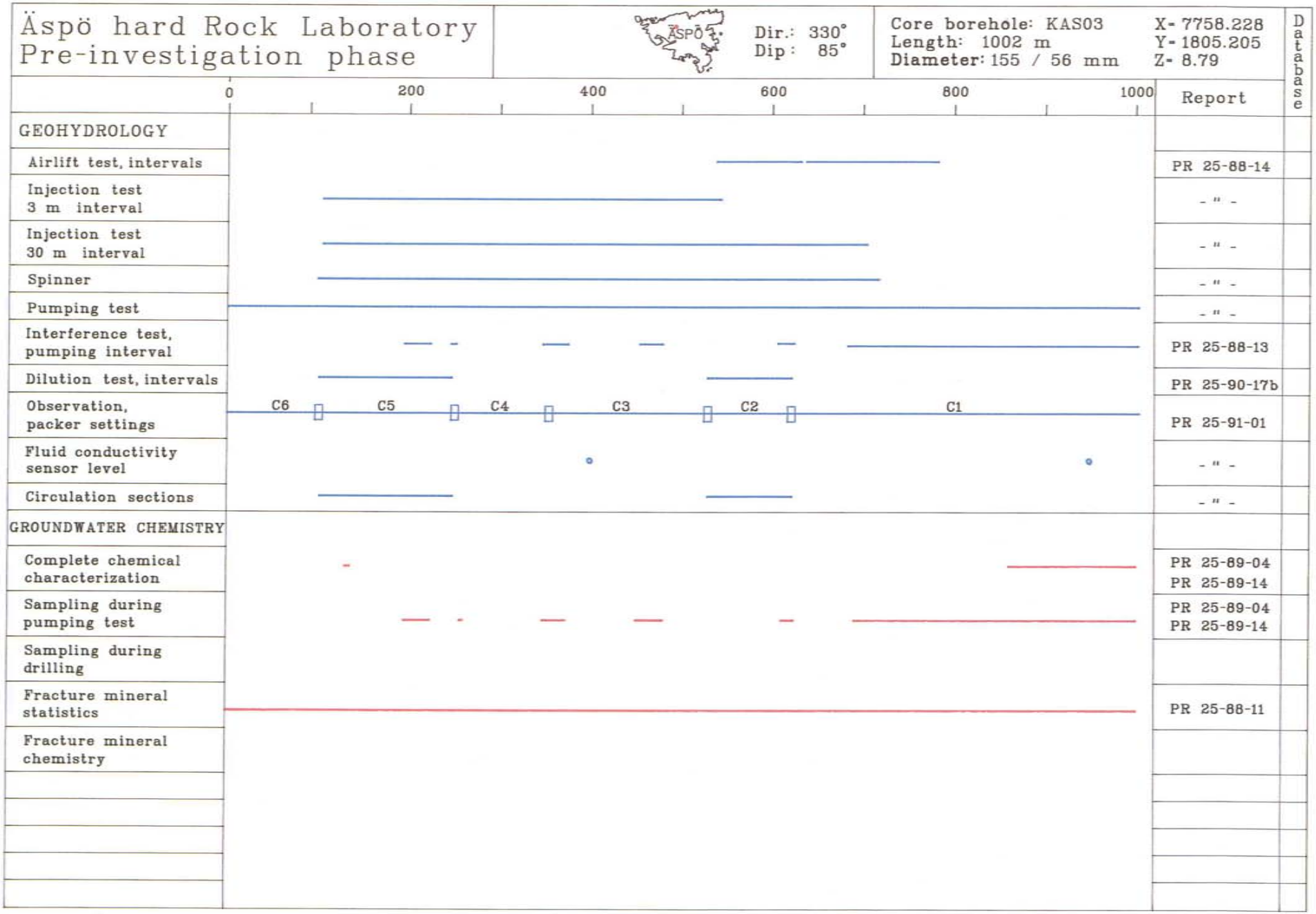


Figure 3-25. KAS 03. Borehole data. Geohydrology and groundwater chemistry.

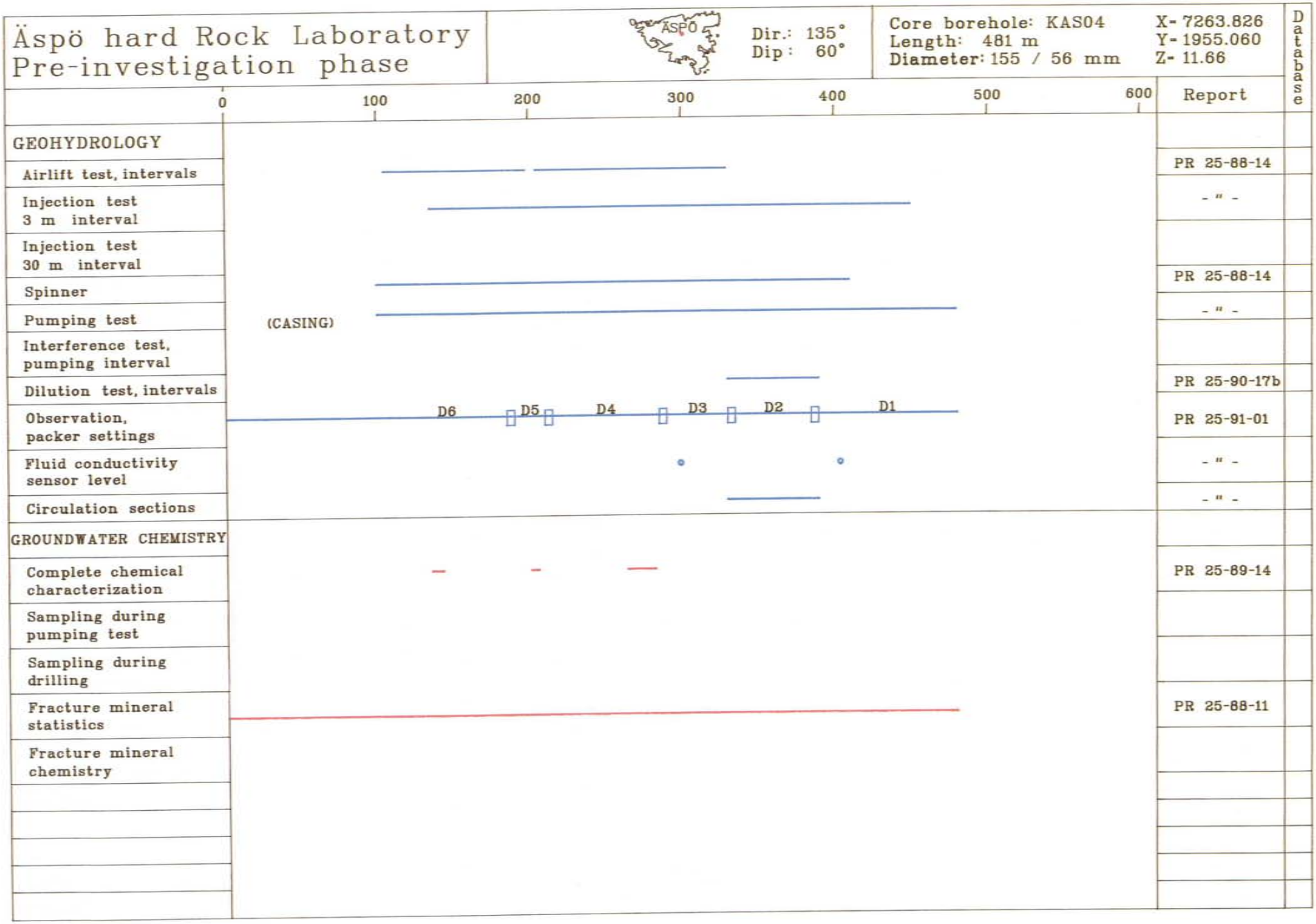


Figure 3-26. KAS 04. Borehole data. Geohydrology and groundwater chemistry.

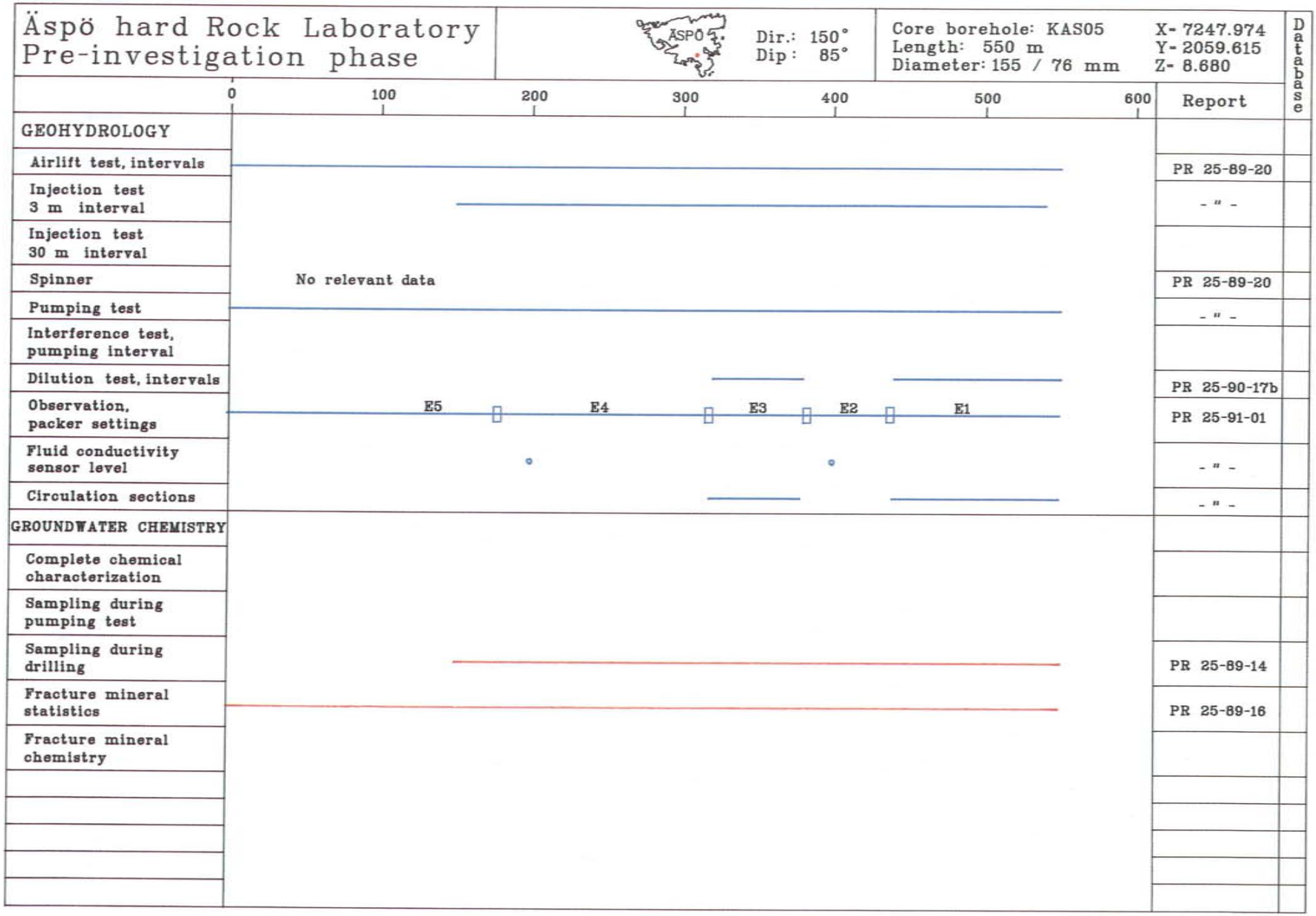


Figure 3-27. KAS 05. Borehole data. Geohydrology and groundwater chemistry.

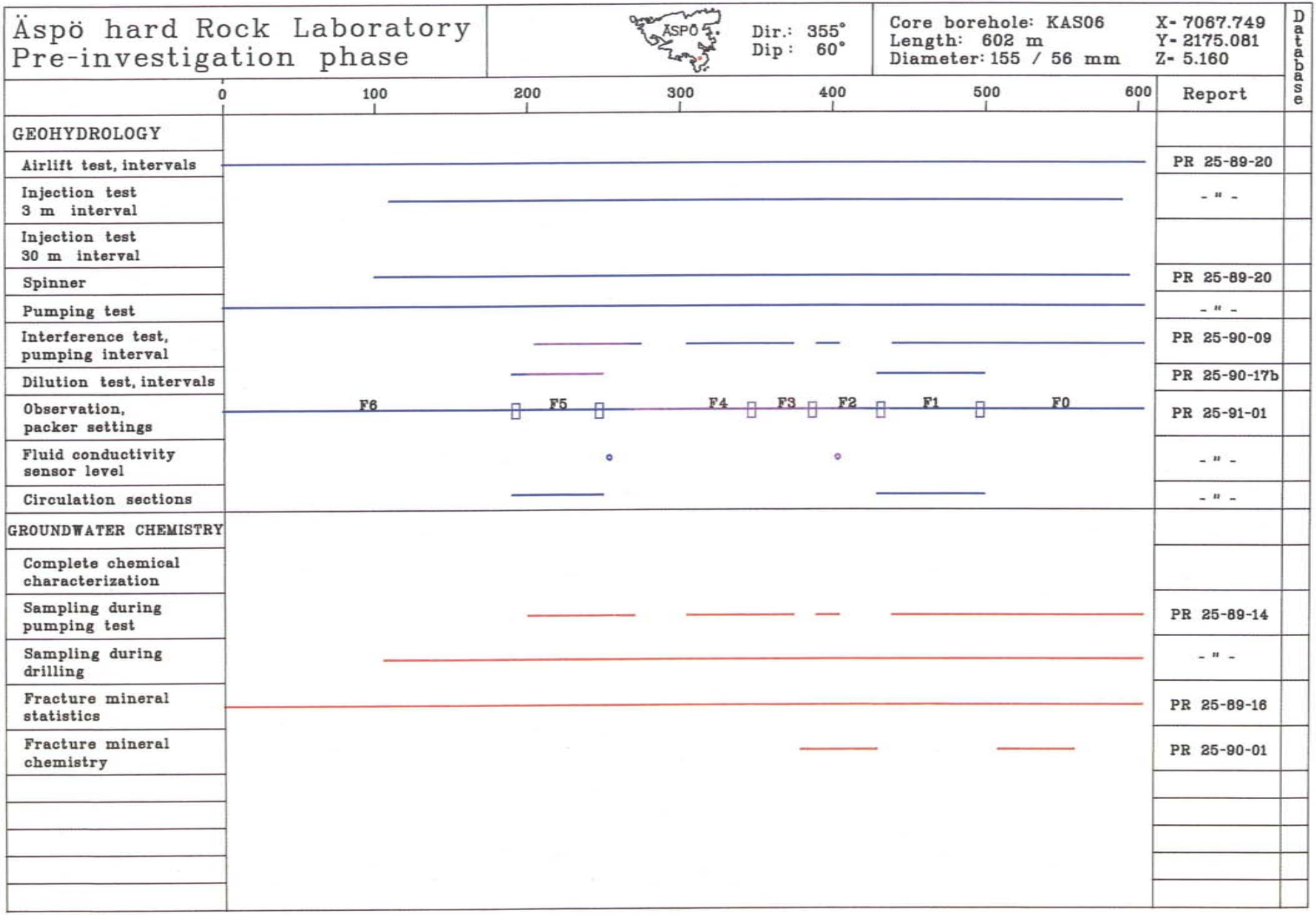


Figure 3-28. KAS 06. Borehole data. Geohydrology and groundwater chemistry.

Äspö hard Rock Laboratory
Pre-investigation phase

Dir.: 205°
Dip: 59°

Core borehole: KAS07
Length: 604 m
Diameter: 155 / 56 mm

X- 7229.662
Y- 2215.403
Z- 4.580

	0	100	200	300	400	500	600	Report	Database
GEOHYDROLOGY									
Airlift test, intervals								PR 25-89-20	
Injection test 3 m interval								- " -	
Injection test 30 m interval									
Spinner								PR 25-89-20	
Pumping test								- " -	
Interference test, pumping interval									
Dilution test, intervals								PR 25-90-17b	
Observation, packer settings	J6	J5	J4	J3	J2	J1		PR 25-91-01	
Fluid conductivity sensor level								- " -	
Circulation sections								- " -	
GROUNDWATER CHEMISTRY									
Complete chemical characterization									
Sampling during pumping test									
Sampling during drilling								PR 25-89-14	
Fracture mineral statistics								PR 25-89-16	
Fracture mineral chemistry									

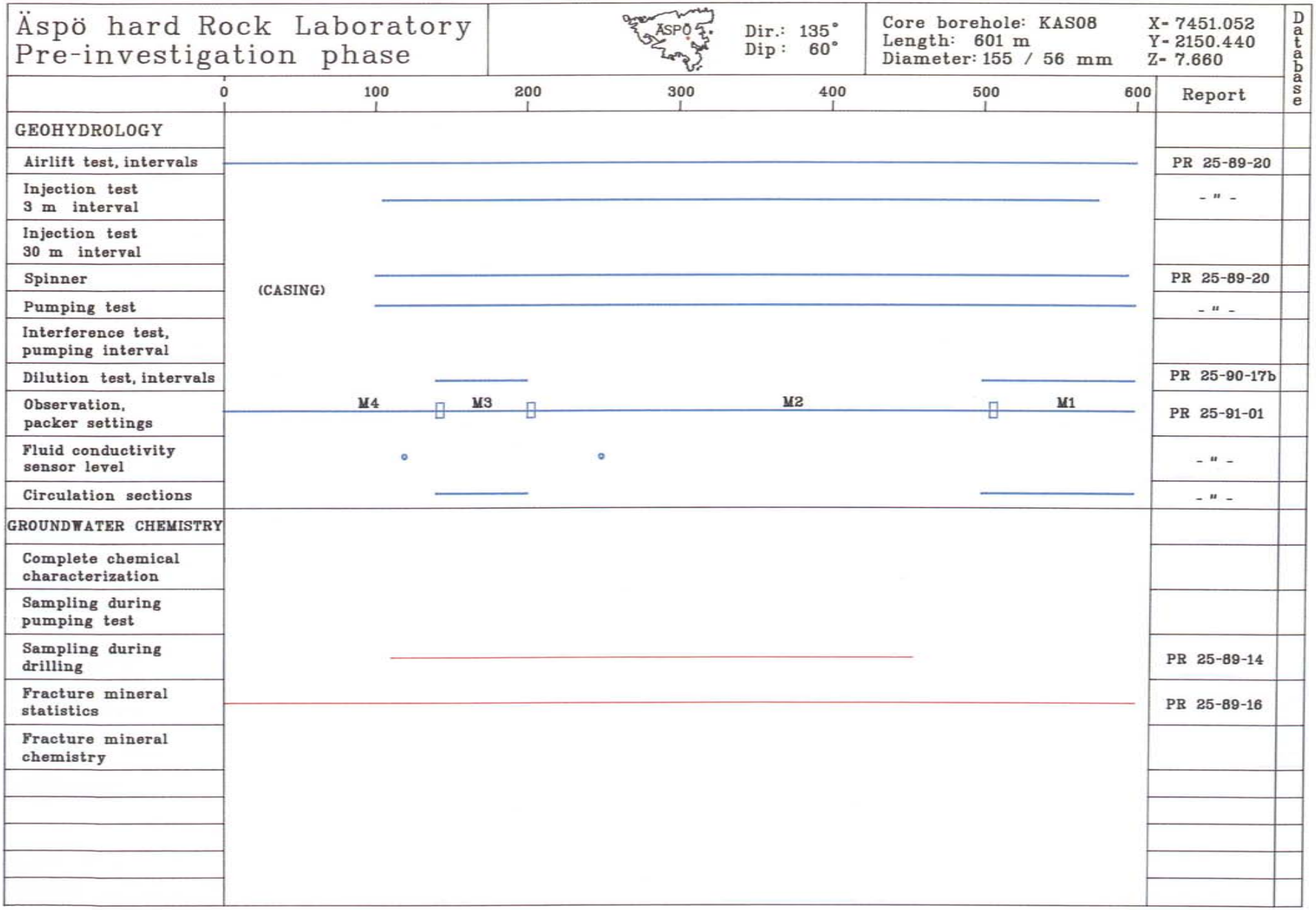


Figure 3-30. KAS 08. Borehole data. Geohydrology and groundwater chemistry.

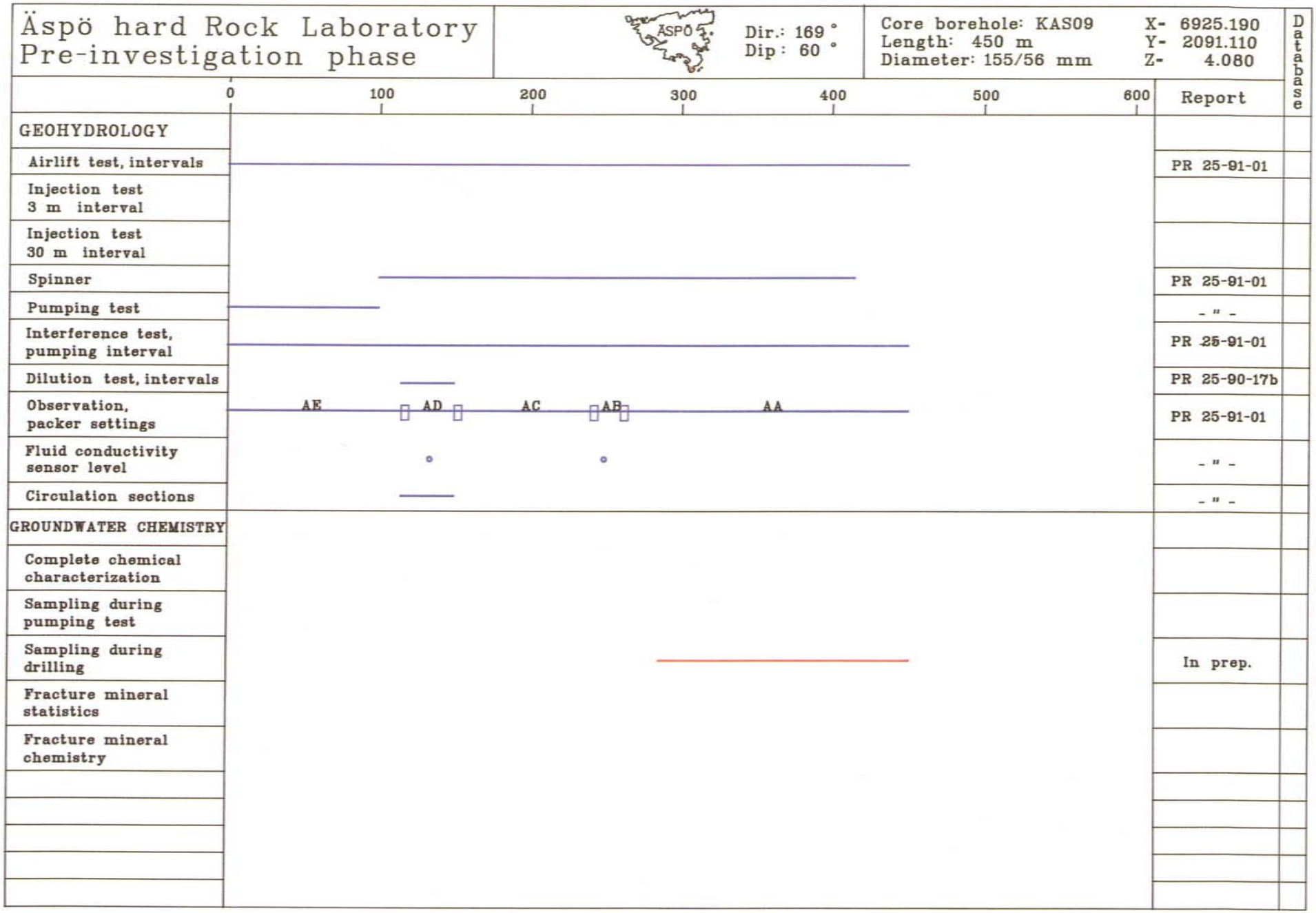


Figure 3-31. KAS 09. Borehole data. Geohydrology and groundwater chemistry.

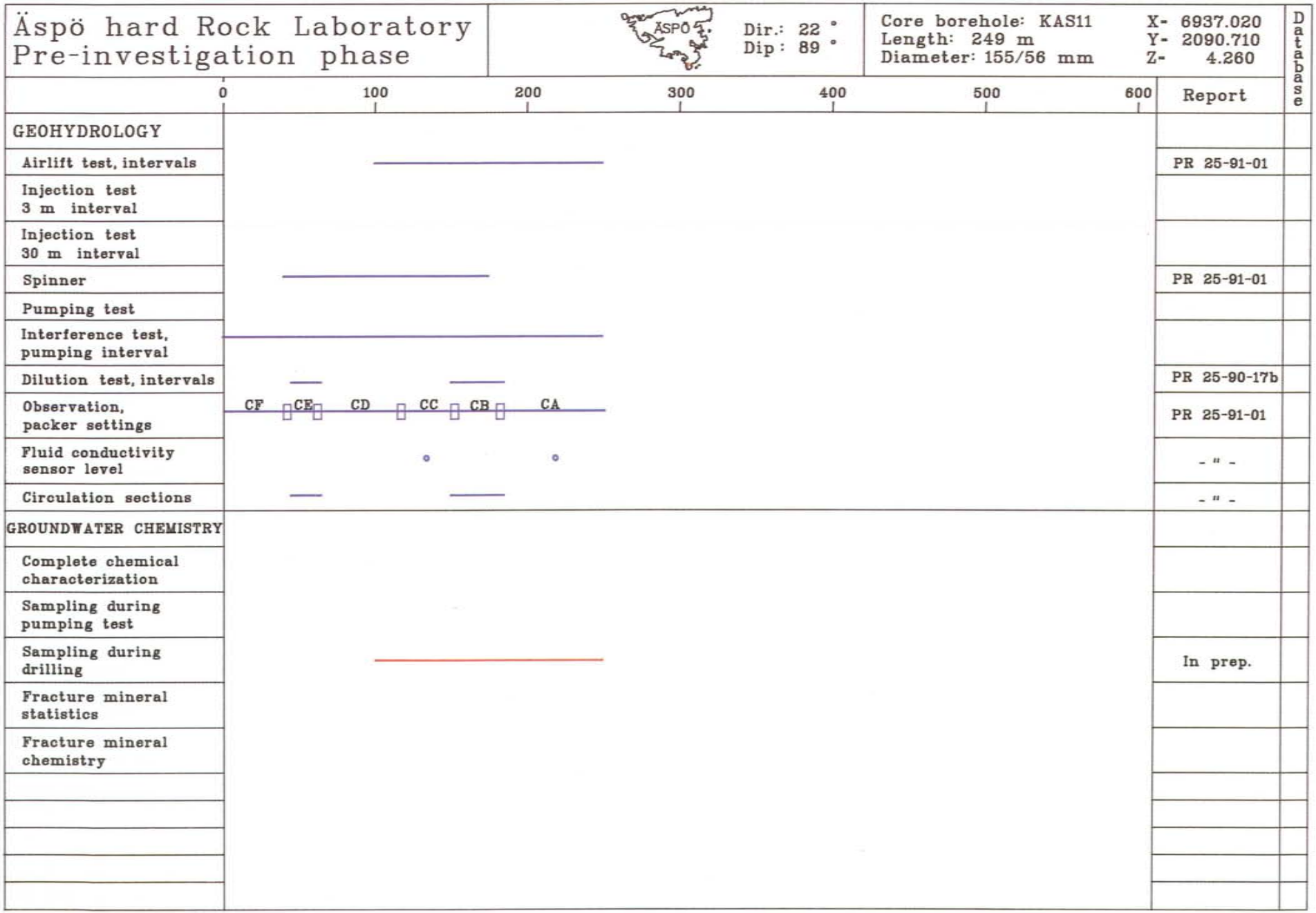


Figure 3-32. KAS 11. Borehole data. Geohydrology and groundwater chemistry.

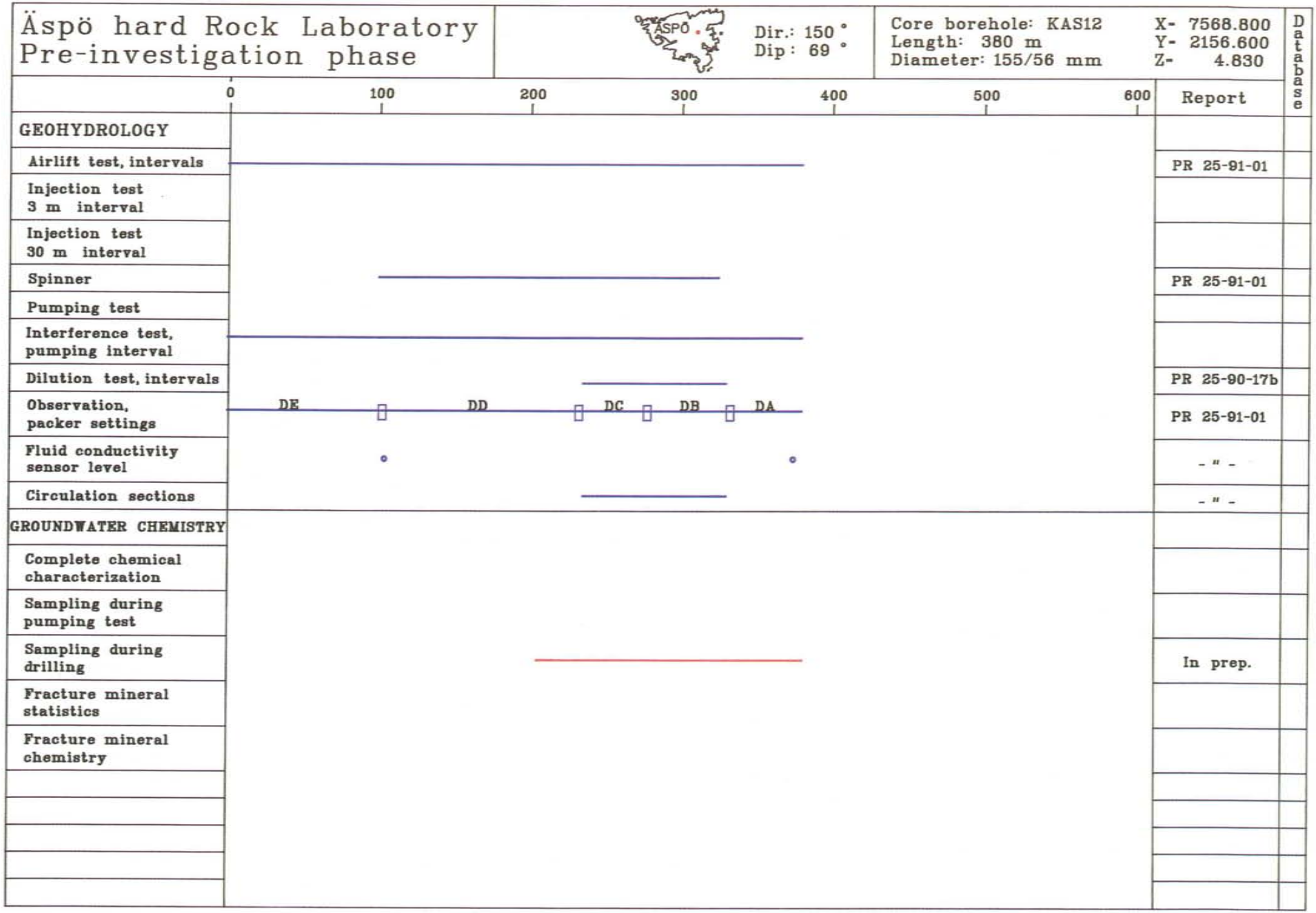


Figure 3-33. KAS 12. Borehole data. Geohydrology and groundwater chemistry.

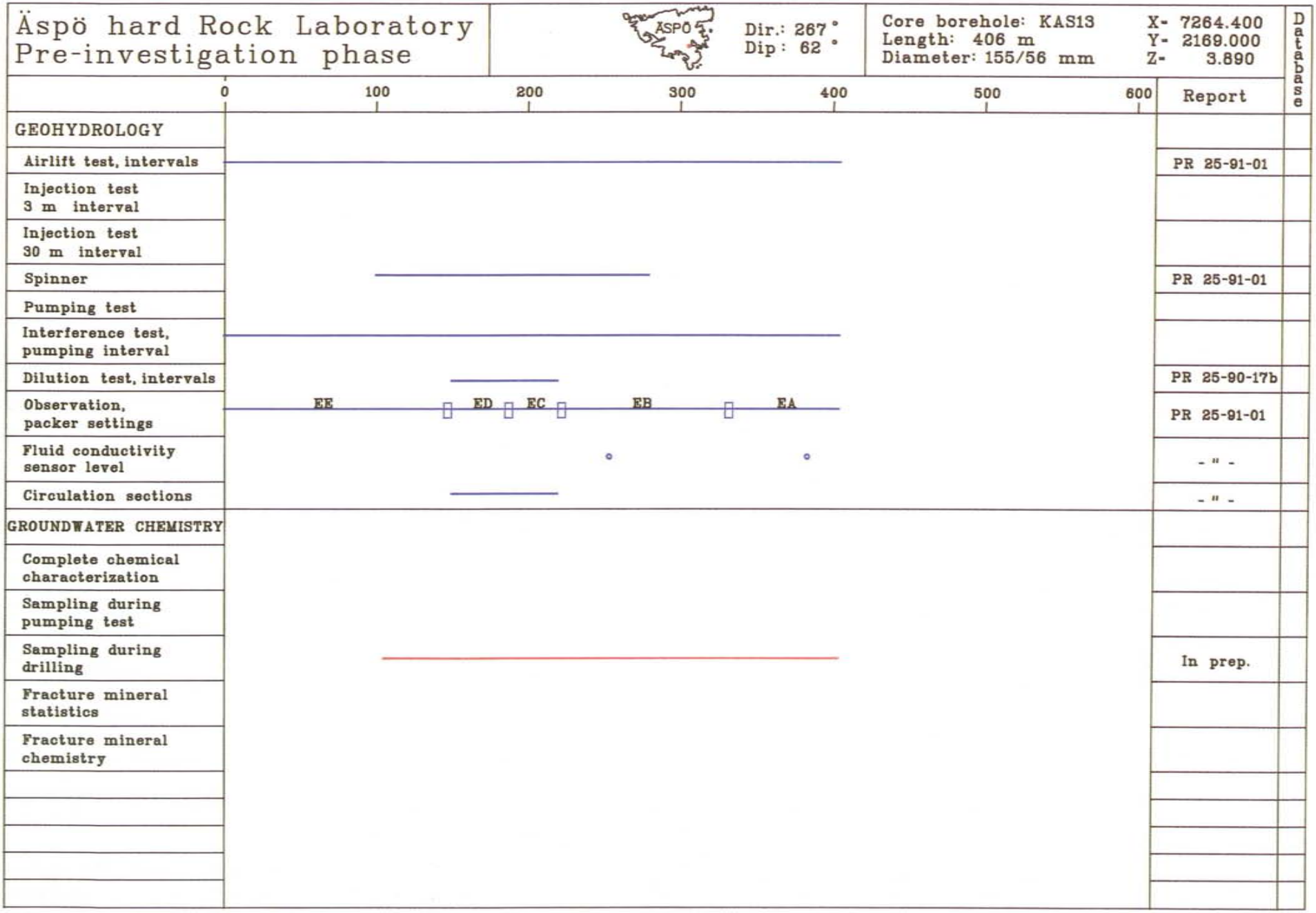


Figure 3-34. KAS 13. Borehole data. Geohydrology and groundwater chemistry.

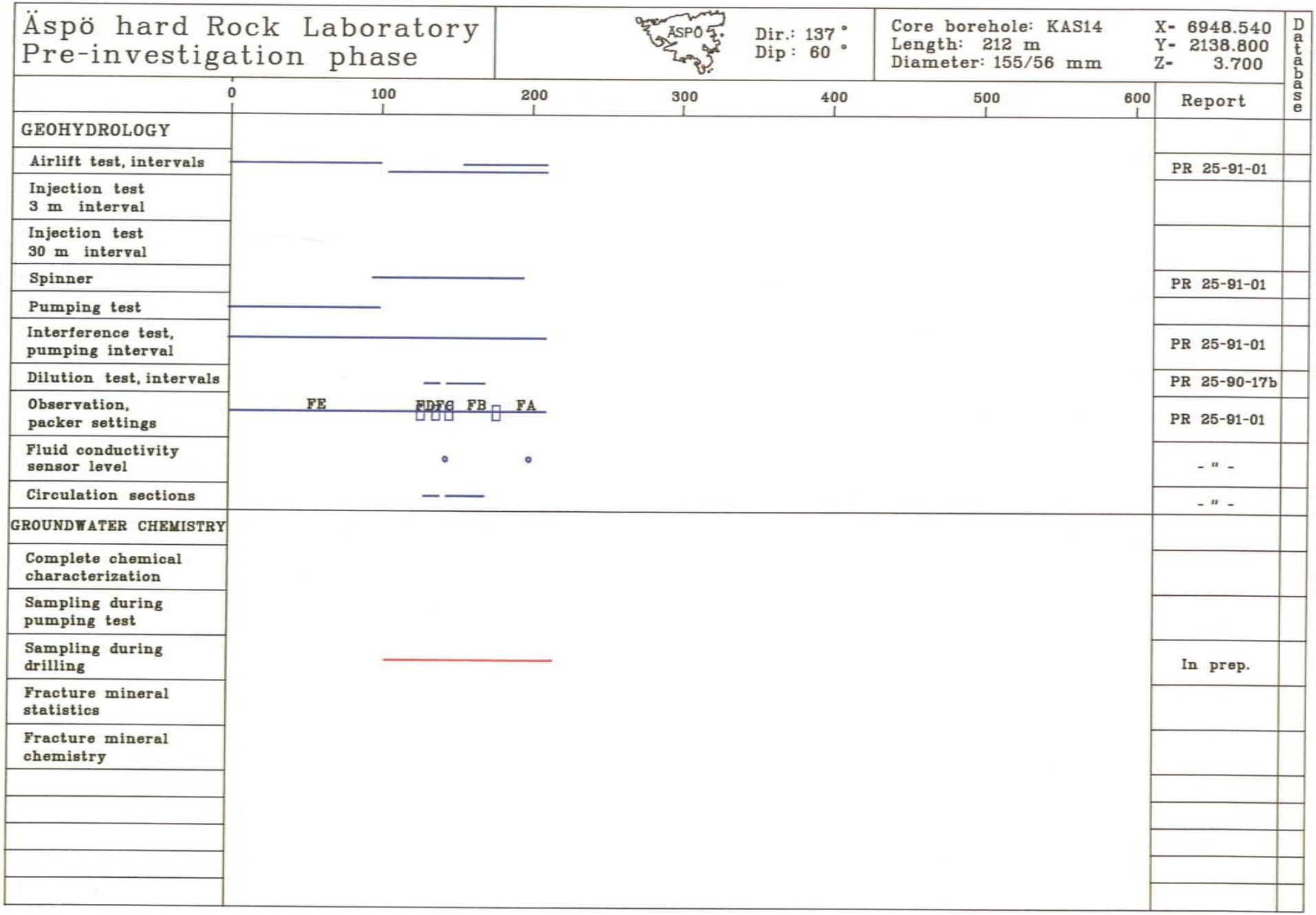


Figure 3-35. KAS 14. Borehole data. Geohydrology and groundwater chemistry.

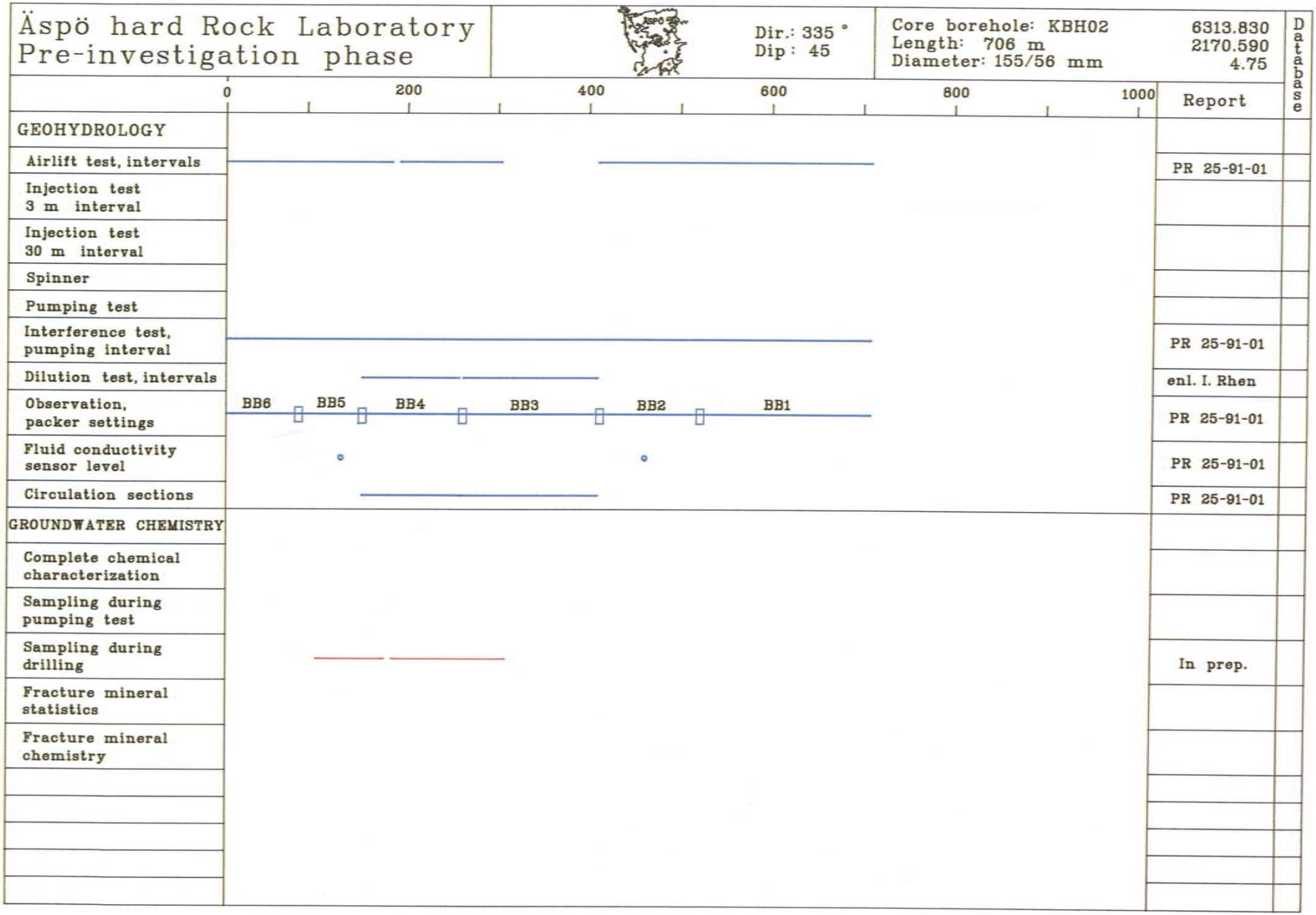


Figure 3-36. KBH 02. Borehole data. Geohydrology and groundwater chemistry.

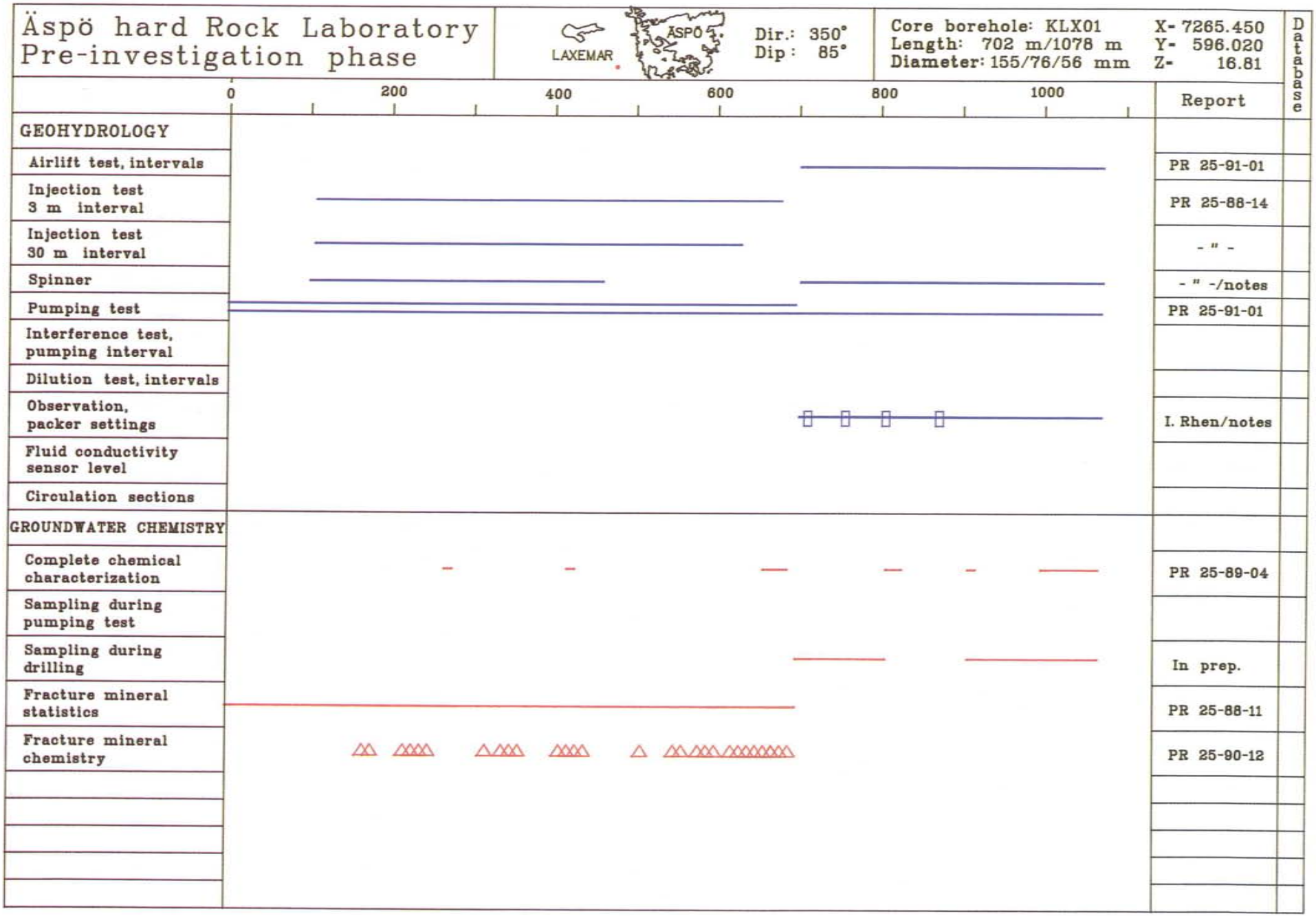


Figure 3-37. KLX 01. Borehole data. Geohydrology and groundwater chemistry.

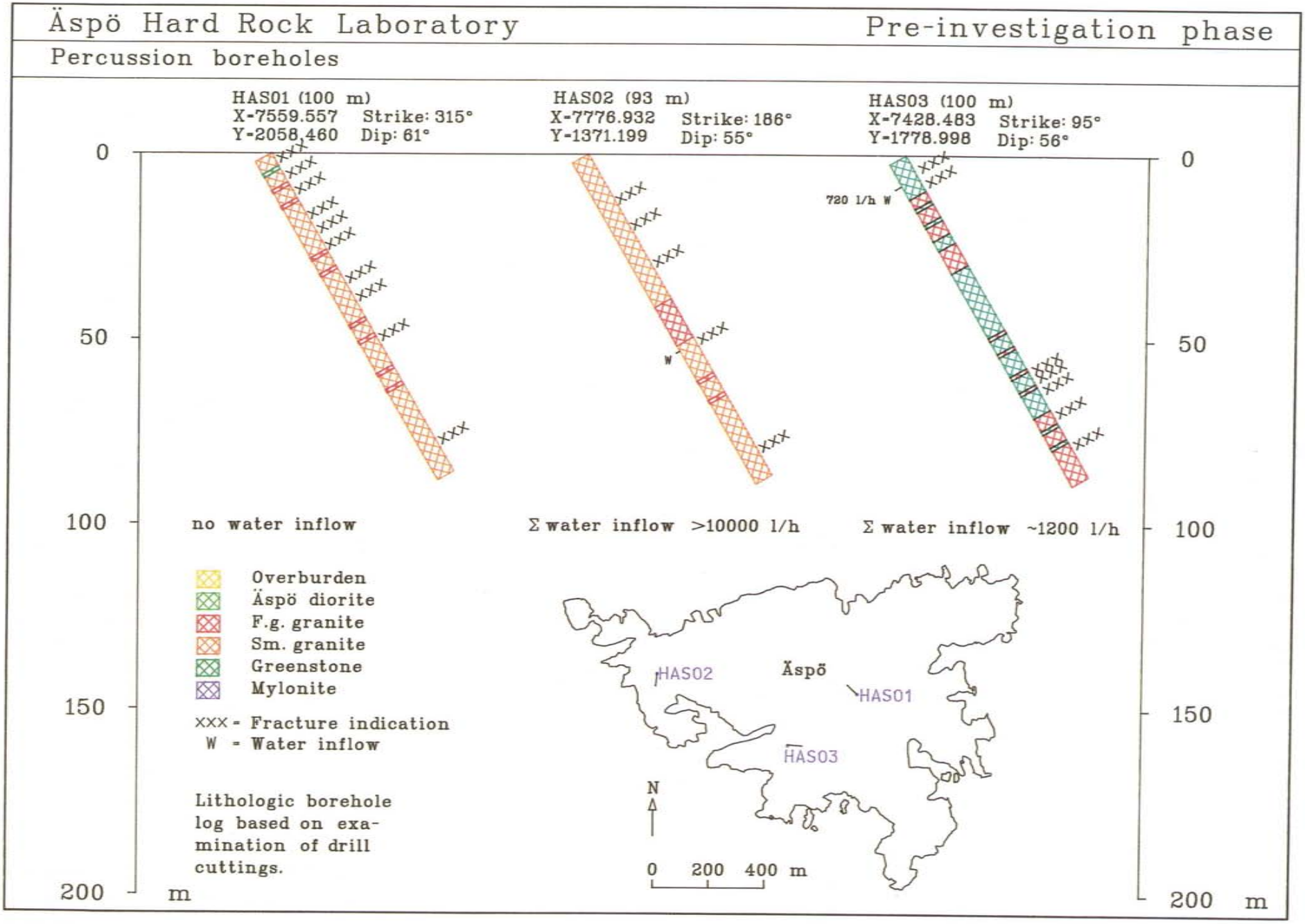


Figure 3-38. Percussion boreholes HAS 01, HAS 02 and HAS 03.

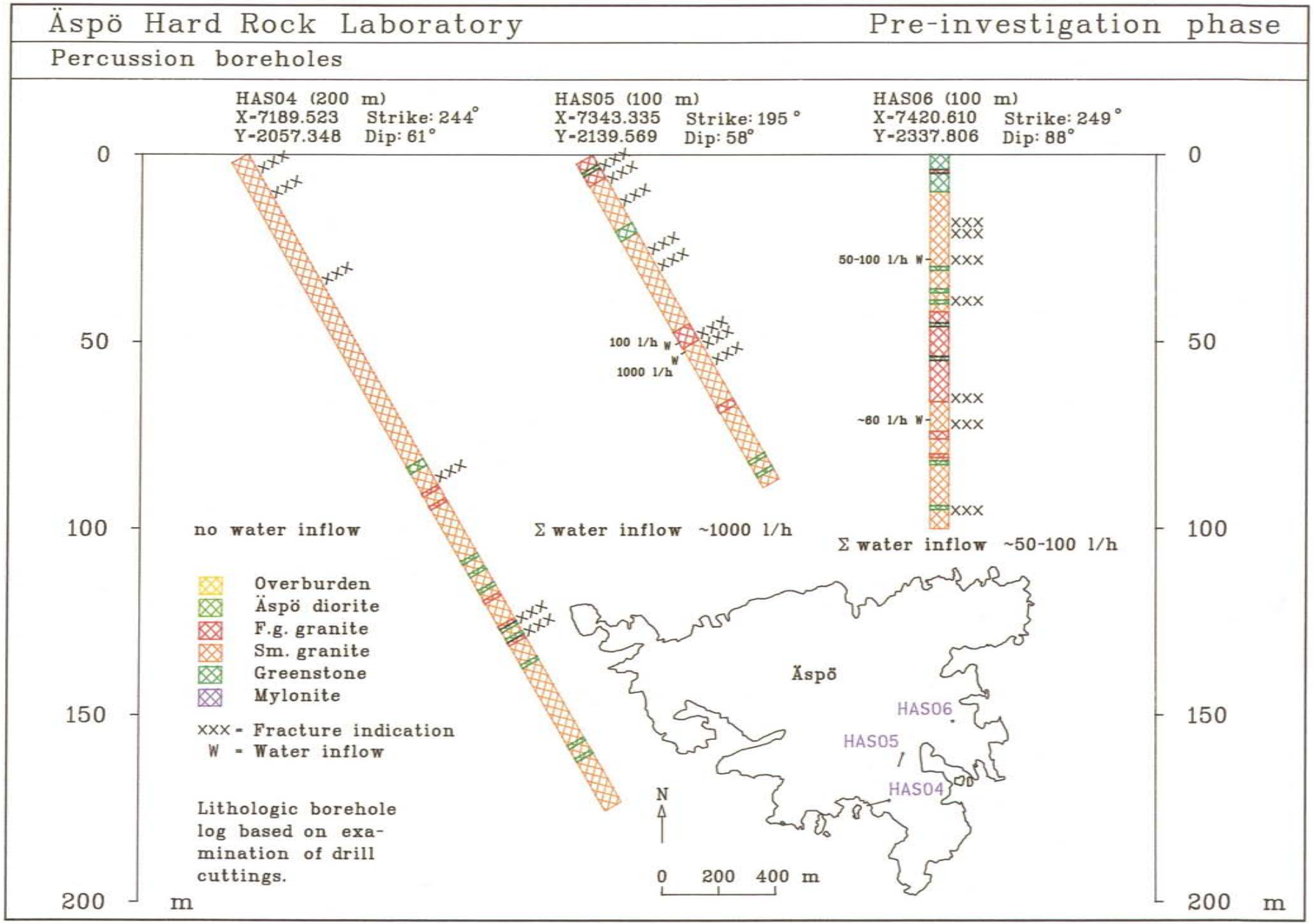


Figure 3-39. Percussion boreholes HAS 04, HAS 05 and HAS 06.

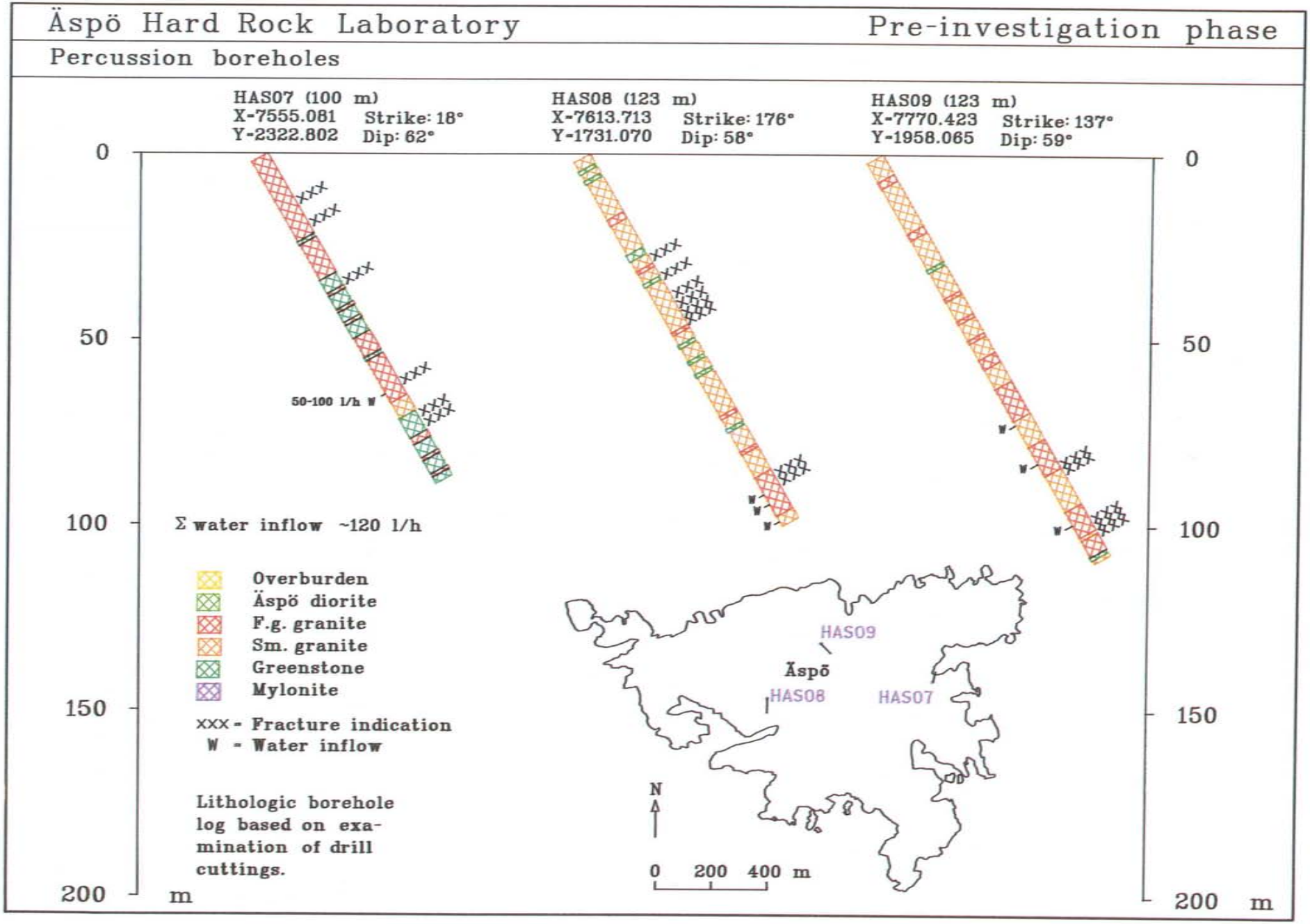


Figure 3-40. Percussion boreholes HAS 07, HAS 08 and HAS 09.

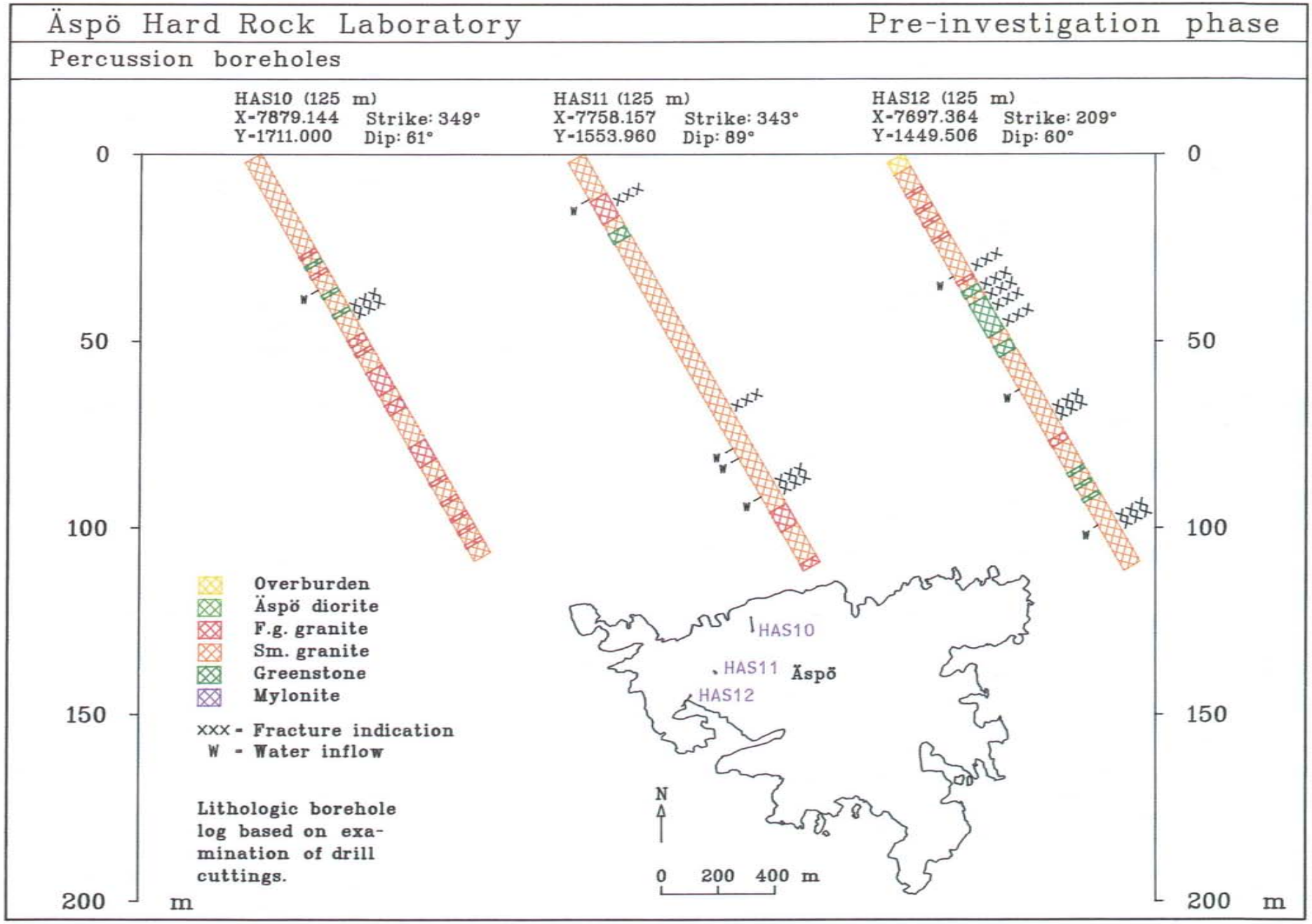


Figure 3-41. Percussion boreholes HAS 10, HAS 11 and HAS 12.

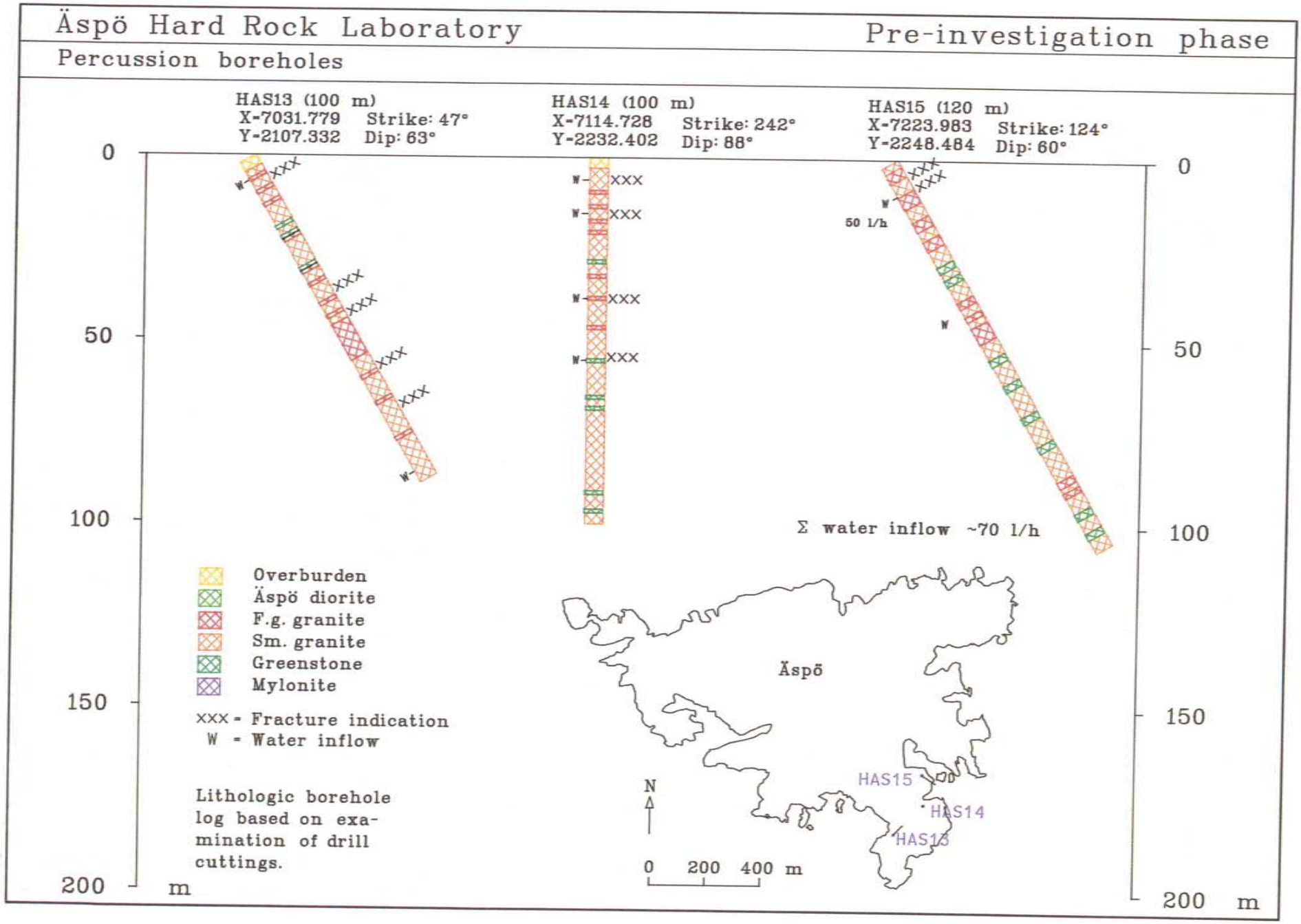


Figure 3-42. Percussion boreholes HAS 13, HAS 14 and HAS 15.

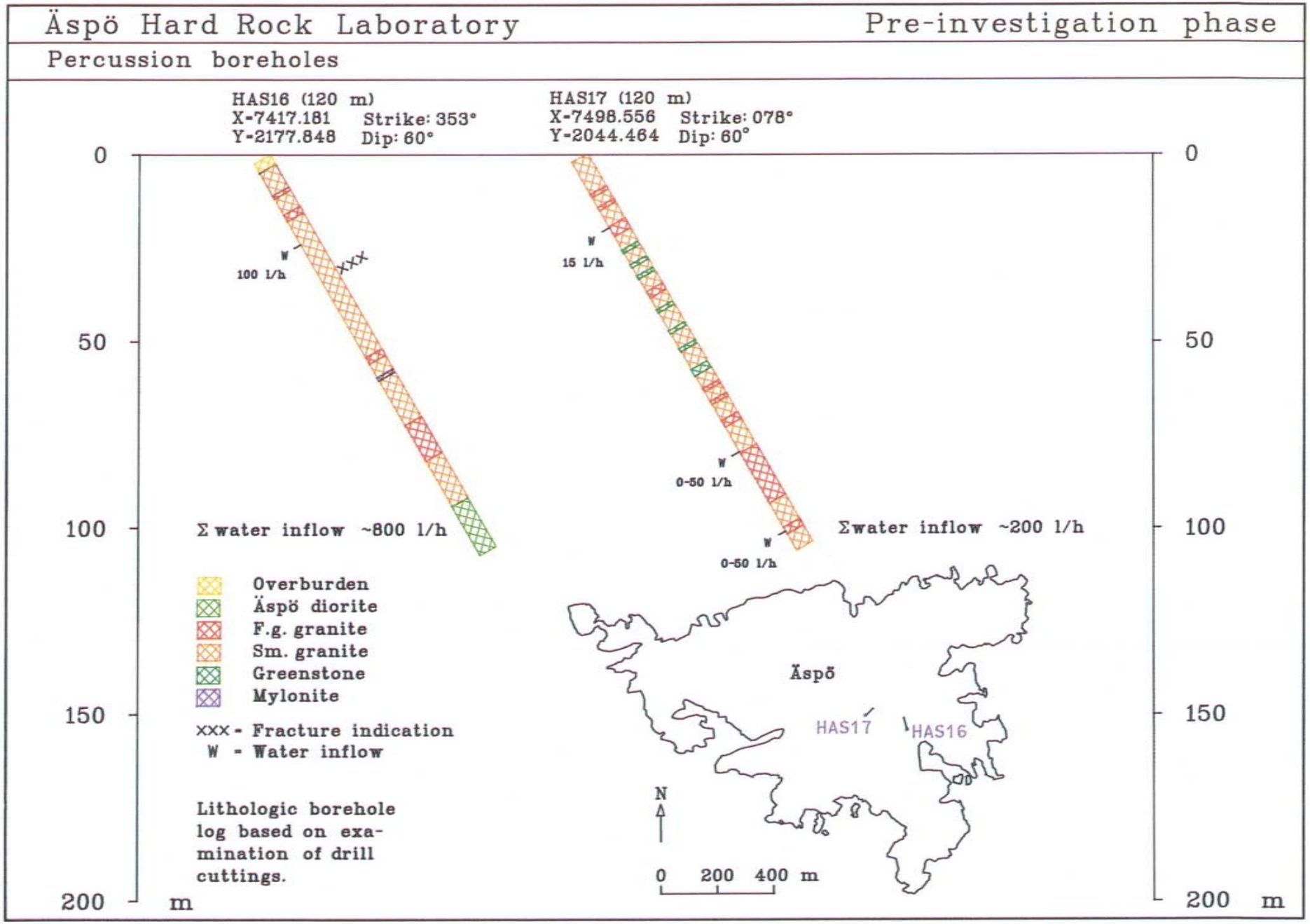


Figure 3-43. Percussion boreholes HAS 16 and HAS 17.

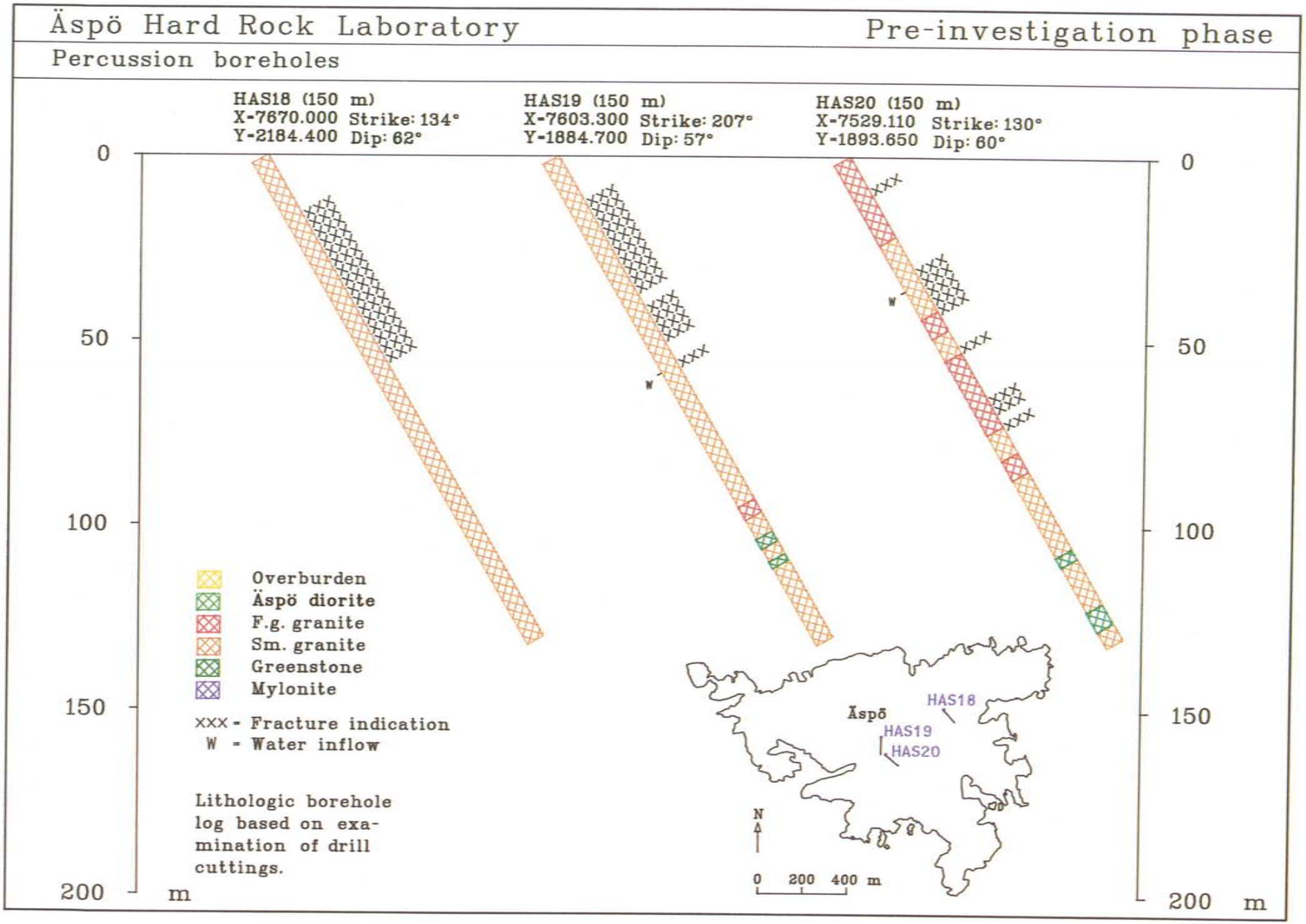


Figure 3-44. Percussion boreholes HAS 18, HAS 19 and HAS 20.

4. APPENDIX

Appendix 1 gives a reference list of the different Progress Reports. The listing is given in chronological order.

LIST OF PROGRESS REPORTS

- Stenberg L. 1987. **Underground research laboratory. Geophysical profile measurements.**
  PR 25-87-01.

  Kornfält K-A, Wikman H. 1987. **Description to the map of solid Rocks around Simpevarp.**
  PR 25-87-02.

- Kornfält K-A, Wikman H. 1987. **Description to the map (No 4) of solid Rocks of 3 small areas around Simpevarp.**
  PR 25-87-02a.

- Talbot C, Riad L. 1987. **Natural fractures in the Simpevarp area.**
  PR 25-87-03.

- Nisca D. 1987. **Aerogeophysical interpretation.**
  PR 25-87-04.

- Ericsson L-O. 1987. **Fracture mapping on outcrops.**
  PR 25-87-05.

- Liedholm M. 1987. **Regional Well Data Analysis.**
  PR 25-87-07.

- Liedholm M. 1987. **Regional Well Water Chemistry.**
  PR 25-87-08.

- Svensson T. 1987. **Hydrological conditions in the Simpevarp area.**
  PR 25-87-09.

- Rhen I. 1987. **Compilation of geohydrological data.**
  PR 25-87-10.

- Nilsson L. 1987. **Hydraulic tests at Ävrö and Äspö.**
  PR 25-87-11.

- Nilsson L. 1988. **Hydraulic tests pumping tests at Laxemar.**
  PR 25-87-11b.

- Axelsson C.L. 1987. **Generic modelling of the SKB rock laboratory.**
  PR 25-87-12.

- Ploug C, Klitten,K. 1988. **Seismical and Geoelectrical test survey on Ävrö, Sweden.**
  PR 25-87-14.

- Sundin,S. 1988. **Seismic refraction investigation at Äspö.**
PR 25-87-15.

- Gentzschein B, Nilsson G, Stenberg L. 1987. **Preliminary Investigations of Fracture Zones at Ävrö - Results of Investigations performed July 1986 - May 1987.**
PR 25-87-16.

Christiansson R. **Characterization of the 240 m level in the AECL Underground Research Laboratory, Manitoba, Canada.**
PR 25-87-17.

- Nylund B. 1987. **Regional gravity survey of the Simpevarp area.**
PR 25-87-20.

Tiren S, Beckholmen M, Isaksson H. 1987. **Structural analysis of digital terrain models, Simpevarp area, South-eastern Sweden. Method study EBBA 11.**
PR 25-87-21.

- Tiren S, Beckholmen M. 1987. **Structural analysis of contoured maps. Äspö and Ävrö South-eastern Sweden**
PR 25-87-22.

- Nisca D. 1987. **Aeromagnetic Interpretation 6G Vimmerby, 6H Kråkelund NW. SW.**
PR 25-87-23.

Larsson J. 1987. **Landsat TM imagery processing and SPE interpretation Västervik-Oskarshamn region.**
PR 25-87-25.

- Tirén S. Beckholmen M. 1988. **Structural analysis of contoured maps. Kärrsvik-Bussvik, Lilla Laxemar and Glostad areas. Simpevarp area. Southeastern Sweden.**
PR 25-87-27.

- Tiren S., Beckholmen M. 1988. **Structural analysis of the Simpevarp sea area. Southeastern Sweden. Linaments and rock blocks.**
PR 25-88-01.

- Hemström B, Svensson U. 1988. **The penetration of sea water into a fresh-water aquifer. A numerical study.**
PR 25-88-02.

- Niva B, Gabriel G. 1988. **Borehole radar measurements at Äspö and Laxemar - Boreholes KAS02, KAS03, KAS04, KLX01, HAS02, HAS03 and HAV07.**
PR 25-88-03.

- Laaksoharju M. 1988. **Shallow groundwater chemistry at Laxemar, Äspö and Ävrö.**
PR 25-88-04.

- Talbot C. Riad L, Munier R. 1988. **The geological Structures and Tectonic history of Äspö SE Sweden.**
PR 25-88-05.

- Nisca D. 1988. **Geophysical laboratory measurements on core samples from KLX 01, Laxemar and KAS02, Äspö.**
PR 25-88-06.

- Stråhle A. 1989. **Drillcore investigation in the Simpevarp area, Boreholes KAS02, KAS03. KAS04, and KLX01**
PR 25-88-07.

- Linden A. 1988. **Radon and Radium Concentrations in ground- and surface water in the Simpevarp area.**
PR 25-88-08.

- Svensson U. 1988. **Numerical simulations of seawater intrusion in fractured porous media.**
PR 25-88-09.

- Ericsson L O. 1988. **Fracture mapping study on Äspö island. Findings of directional data.**
PR 25-88-10.

- Munier R, Riad L, Tullborg E-L, Wikman H, Kornfält K-A. 1988.
Detailed investigation of drillcores KAS02, KAS03 and KAS04 on Äspö island and KLX01 at Laxemar.
PR 25-88-11.

- Kornfält K-A, Wikman H. 1988. **The rocks of the Äspö island. Description to the detailed maps of solid rocks including maps of 3 uncovered trenches.**
PR 25-88-12.

- Rhen I. 1989. **Transient interference tests on Äspö 1988. Evaluation**
PR 25-88-13.

- Nilsson L. 1989. **Hydraulic tests at Äspö and Laxemar. Evaluation.**
PR 25-88-14.

- Sehlstedt S, Triumf C-A. 1988. **Interpretation of geophysical logging data from KAS 02 - KAS04 and HAS08 - HAS12 at Äspö and KLX01 at Laxemar.**
PR 25-88-15.

- Barmen G, Stanfors R. 1988. **Ground level geophysical measurements on the island of Äspö.**
PR 25-88-16.

- Gustafson G, Liedholm M, Lindbom B, Lundblad K. 1989. **Groundwater Flow Calculations on a Regional Scale at the Swedish Hard Rock Laboratory.**
PR 25-88-17.

- Stanfors R. 1988. **Geological Borehole Description KAS02, KAS03, KAS04, KLX01.**
PR 25-88-18.

- Nisca D, Triumf C-A. 1989. **Detailed geomagnetic and geo-electric mapping of Äspö.**
PR 25-89-01.

- Ploug C, Klitten K. 1989. **Shallow reflection seismic profiles from Äspö, Sweden.**
PR 25-89-02.

- Liedholm M. 1989. **Combined evaluation of geological, hydrogeological and geophysical information 1.**
PR 25-89-03.

- Laaksoharju M, Nilsson A-C. 1989. **Models of groundwater composition and of hydraulic conditions based on chemometrical and chemical analyses of deep groundwater at Äspö and Laxemar.**
PR 25-89-04.

- Thunvik R, Braester C,.1989. **Preliminary calculation of the flow conditions at prospective study site for the Swedish Hard Rock Laboratory.**
PR 25-89-05 (in print)

- Wikström A. 1989. **General geological-tectonic study of the Simpevarp area with special attention to the Äspö island**
PR 25-89-06.

- Stille H, Olsson P. 1989. **First evaluation of rock mechanics**
  PR 25-89-07.

- Fridh B, Stråle A. 1989. **Orientation of selected drillcore sections from the boreholes KAS05 and KAS06 Äspö, Sweden. A Televiewer investigation in small diameter boreholes.**
  PR 25-89-08.

- Sehlstedt S, Stråhle A. 1989. **Geological core mapping and geophysical borehole logging in the boreholes KAS05 - KAS08 at Äspö.**
  PR 25-89-09.

- Carlsten S. 1989. **Results from borehole radar measurements in KAS05, KAS06, KAS07 and KAS08 at Äspö. Interpretation of fracture zones by including radar measurements from KAS02 and KAS04.**
  PR 25-89-10.

- Talbot C, Munier R. 1989. **Faults and fracture zones in Äspö.**
  PR 25-89-11.

- Sandberg E, Forslund O, Olsson O. 1989. **Ground surface radar measurements at Äspö.**
  PR 25-89-12.

- Stenberg L, Sehlstedt S. 1989. **Geophysical profile measurements on interpreted regional aeromagnetic lineaments in the Simpevarps area.**
  PR 25-89-13.

- Nilsson A-C. 1989. **Chemical characterization of deep groundwater on Äspö. 1989.**
  PR 25-89-14.

- Munier R. 1989. **Brittle tectonics on Äspö, SE Sweden.**
  PR 25-89-15.

- Tullborg E-L. 1989. **Fracture fillings in the drillcores KAS05 - KAS08 from Äspö, Southeastern Sweden.**
  PR 25-89-16.

- Bjarnason B, Klasson H, Leijon B, Strindell L, Öhman T. 1989. **Rock stress measurements in boreholes KAS02, KAS03 and KAS05 on Äspö.**
  PR 25-89-17.

- Rydström H, Gereben L.1989. **Seismic refraction survey on Äspö and Hålö.**
PR 25-89-18.

- Triumf, Sehlstedt. 1989. **Magnetic measurements over Borholmsfjärden between Äspö and Hålö**
PR 25-89-19.

- Nilsson L. 1990. **Hydraulic tests at Äspö KAS05 - KAS08. HAS 13 -HAS 17. Evaluation**
PR 25-89-20.

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