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Oskarshamn site investigation

Identification of lineaments in the Simpevarp area by the interpretation of topographical data

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May 2003

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Keywords: lineament, Simpevarp, Oskarshamn, topographical data, elevation data, fracture zones, deformation.

Contents

1 Introduction

This document reports the results gained in the activity "Identification of lineaments in the Simpevarp area by the interpretation of topographical data". It is one of the activities performed within the site investigation at Oskarshamn.

The work was carried out by GeoVista AB during the winter and spring of 2003 following the instruction and guidelines from SKB (activity plan AP PS 400-03-009 and method description SKB MD 120.001, SKB internal controlling documents) under the supervision of Peter Hultgren, SKB.

Before the site investigations started at Oskarshamn, existing data and interpretations were compiled at a regional scale to create the first version of the site descriptive model – model version 0 /1/. The model will successively be upgraded during the site investigation and one of the data sets which will be used for future upgrades is the result from the current report.

"Identification of lineaments in the Simpevarp area by the interpretation of topographical data" strives to achieve more information regarding the deformation of the bedrock on both regional and local scale in the Simpevarp area. The activity has been based on results from the airborne photography which was carried out in 2001 over the area /2/. The photo-session resulted in a new terrain model and high-resolution images. The elevation data have been interpreted in order to identify lineaments. In the interpretation process, the infra-red images have served as control of identified lineaments.

The interpretation has covered the majority of the land-covered part of the Simpevarp regional model area Figure 1-1. Minor land covered parts in the north-west of the regional model area were however left out due to lack of new elevation data.

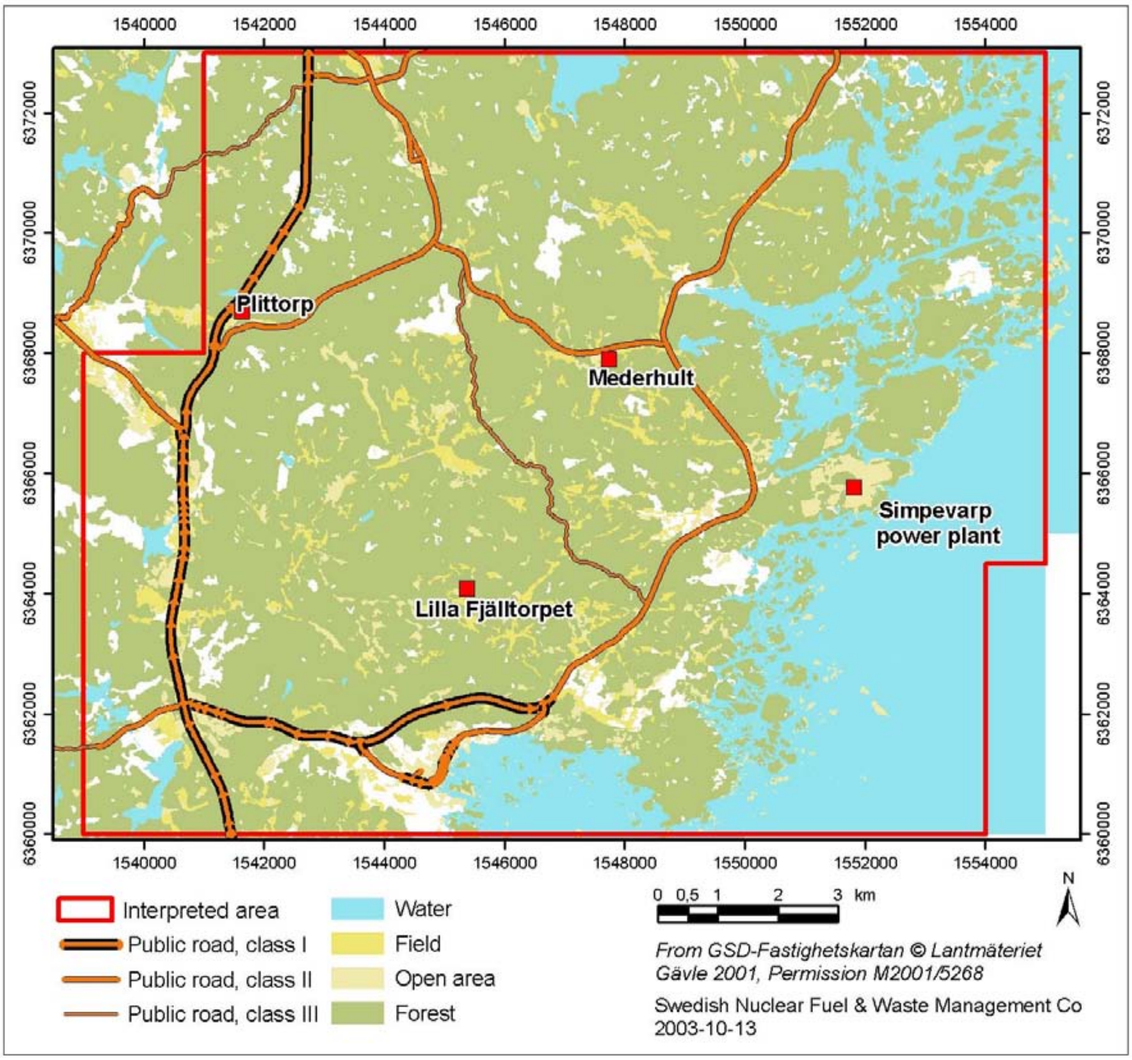

Figure 1-1. *The Simpevarp regional model area and the area where lineaments have been identified by the interpretation of topographical data.*

2 Objective and scope

The objective of this reported activity is to identify lineaments, primarily from the new elevation data. Identified lineaments may indicate deformation zones and hence they provide a base for the upgrade of the structural model, which is part of the site descriptive model. The interpretation covers an area of approximately 190 km^2 , Figure 1-1.

The focus of the activity has been to identify lineaments on land. The eastern part of the regional model area is covered by the Baltic Sea where marine geological surveys have been carried out. Data from the marine survey was not available for the current work.

It is beyond the scope of this activity to analyse the possible genesis of the identified lineaments, and as a consequence the lineaments identified have in general not been compared with other existing data. A joint interpretation, considering the relations of the lineaments identified in topographical data with geological observations and lineaments identified in airborne geophysical data, is planned to be carried out in a separate activity.

3 Equipment

3.1 Description of equipment

Essentially the identification process is a pure desk-top study based on the use of computers with appropriate software. The software used for filtering, transformation and visualisation of elevation data has been OASIS montaj (Geosoft Inc). The interpretation and the presentation of results was made with MapInfo (MapInfo Corp) and ArcView (ESRI).

4 Execution

The process of identification is described in the method description for the interpretation of topograhical data (SKB MD 120.001, SKB internal controlling document). Though the guide lines given in the method description are followed, a high degree of personal judgement must be introduced in the interpretation process. This is most pronounced regarding decisions of how different lineaments may or may not be connected with each other.

The process of identification consists of preparatory work, identification and parametrization of lineaments, reporting, and delivery of digital information and report.

The preparatory work includes gathering of data, filtering and visualisation of data. The products, i.e. images of elevation data presented in different ways, were prepared for GIS.

As the Quaternary deposits in general are thin in the interpreted area, the elevation data are considered to give the most diagnostic information among the topographical data, regarding possible deformation zones. Hence the aerial photographs and the map “Fastighetskartan” have been used only for control of a few suspicious lineaments.

Vast local depressions in the elevation are scattered all over the interpreted area. If their geometrical extent is large, or if they have a geometrical form which does not reveal signs of possibly hidden lineaments, the depressions may hide deformed rock. Such depressions have been identified and delineated separately, the assignment of attributes to depressions is however different as compared to the lineaments. The maps showing local depressions should be viewed together with the maps showing lineaments. The same applies also to areas covered with water, which implies that the interpretation should be viewed also with water-filled areas marked.

4.1 Preparations and data handling

Elevation data were prepared for GIS in the OASIS Montaj (Geosoft Inc) where a number of digital image processing techniques were applied to prepare a number of grids for export to MapInfo (MapInfo Corp) and ArcView (ESRI) formats.

The grids adapted to GIS are specified in Table 4-1.

Table 4-1. Specification of data grids adapted to GIS containing elevation data used in the identification of lineaments from topographical data. The grid files delivered to SKB have a mixture of Swedish and English file names which are also used in this document to avoid confusion.

Primary data	Processing	Name of resulting grid adapted to GIS (format)
Elevation data from the airborne photo session 2001 at altitude 2300 m.	Minimum Curvature Gridding, cell size 10 m, colour table.	Simpevarp_höjd_2300m_gridcell10m (MapInfo-tif) Simpevarp_höjd_2300m_gridcell10m_avtif (ArcView-tif)
Elevation data from the airborne photo session 2001 at altitude 2300 m.	Minimum Curvature Gridding, cell size 10 m. AGC applied, filter size 10, Maximum Gain correction 10, Full Amplitude, colour table.	Simpevarp_höjd_agc_2300m_gridcell10m (MapInfo-tif) Simpevarp_höjd_agc_2300m_gridcell10m_avtif (ArcView-tif)
Elevation data from the airborne photo session 2001 at altitude 2300 m.	Minimum Curvature Gridding, cell size 10 m, High Pass Filtering with Butterworth filter 0.005, 1 and hp (Oasis Montaj), colour table, shading with vertical light.	Simpevarp_höjd_hp_005__2300m_gridcell10m (MapInfo-tif) Simpevarp_höjd_hp_005__2300m_gridcell10m _avtif (ArcView-tif)
Elevation data from the airborne photo session 2001 at altitude 2300 m.	Minimum Curvature Gridding, cell size 10 m, third order trend removed, all points used, colour table.	Simpevarp_höjd_trendremoved_2300m_gridcell10m (MapInfo-tif) Simpevarp_höjd_trendremoved_2300m_gridcell10m _avtif (ArcView-tif)
Elevation data from the airborne photo session 2001 at altitude 2300 m.	Minimum Curvature Gridding, cell size 10 m, third order trend removed, all points used, colour table, shading with vertical light.	Simpevarp_höjd_trendremoved_shaded_2300m_gridcell10m (MapInfo-tif) Simpevarp_höjd_trendremoved_shaded_2300m_gridcell10m _avtif (ArcView-tif)

The five grids are presented in Figures 4-1 to 4-5.

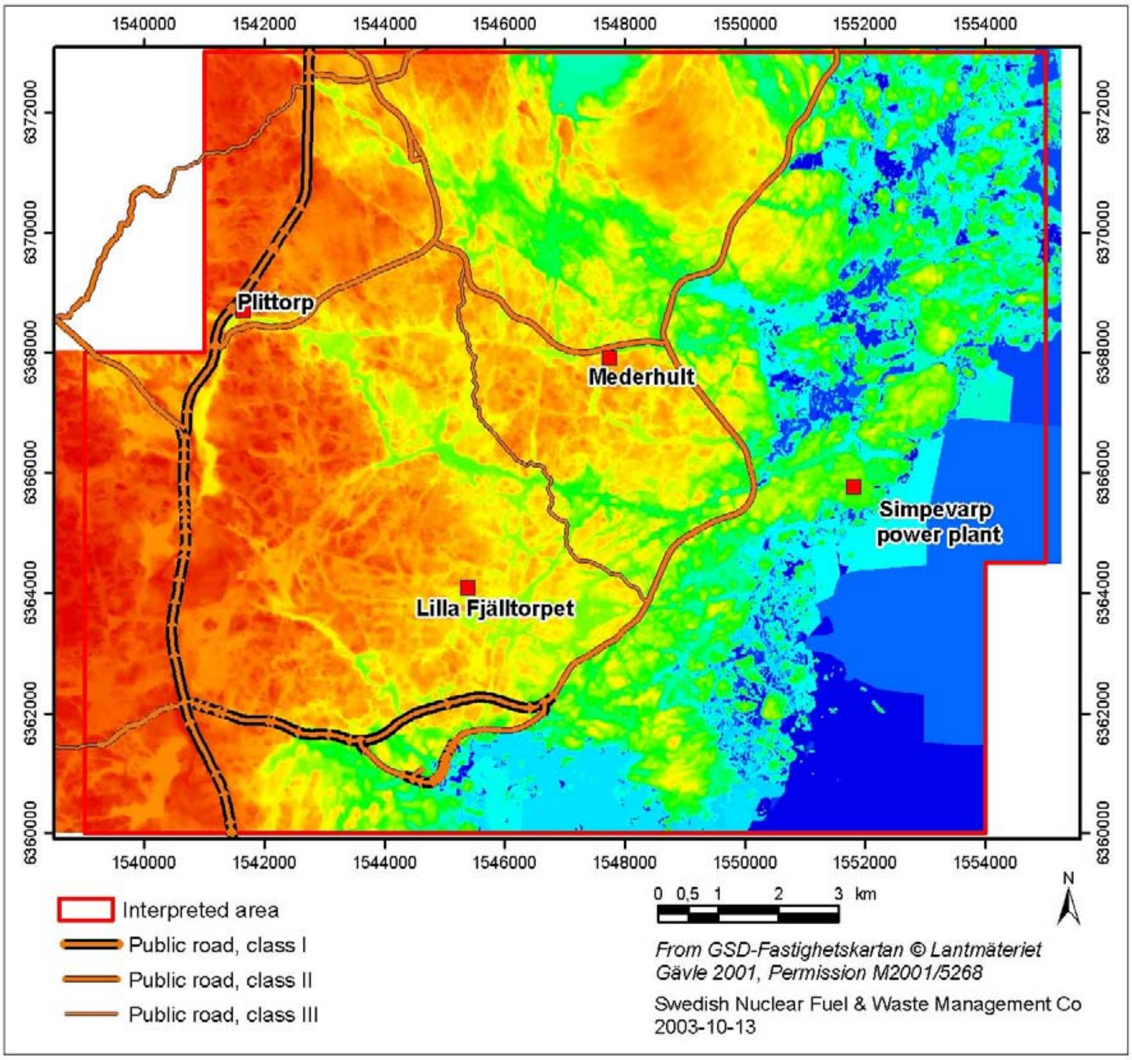

***Figure 4-1**. Simpevarp_höjd_2300m_gridcell10m. The grid shows absolute altitudes where red colour indicates higher altitudes. The grid files delivered to SKB have a mixture of Swedish and English file names which are also used in this document to avoid confusion.*

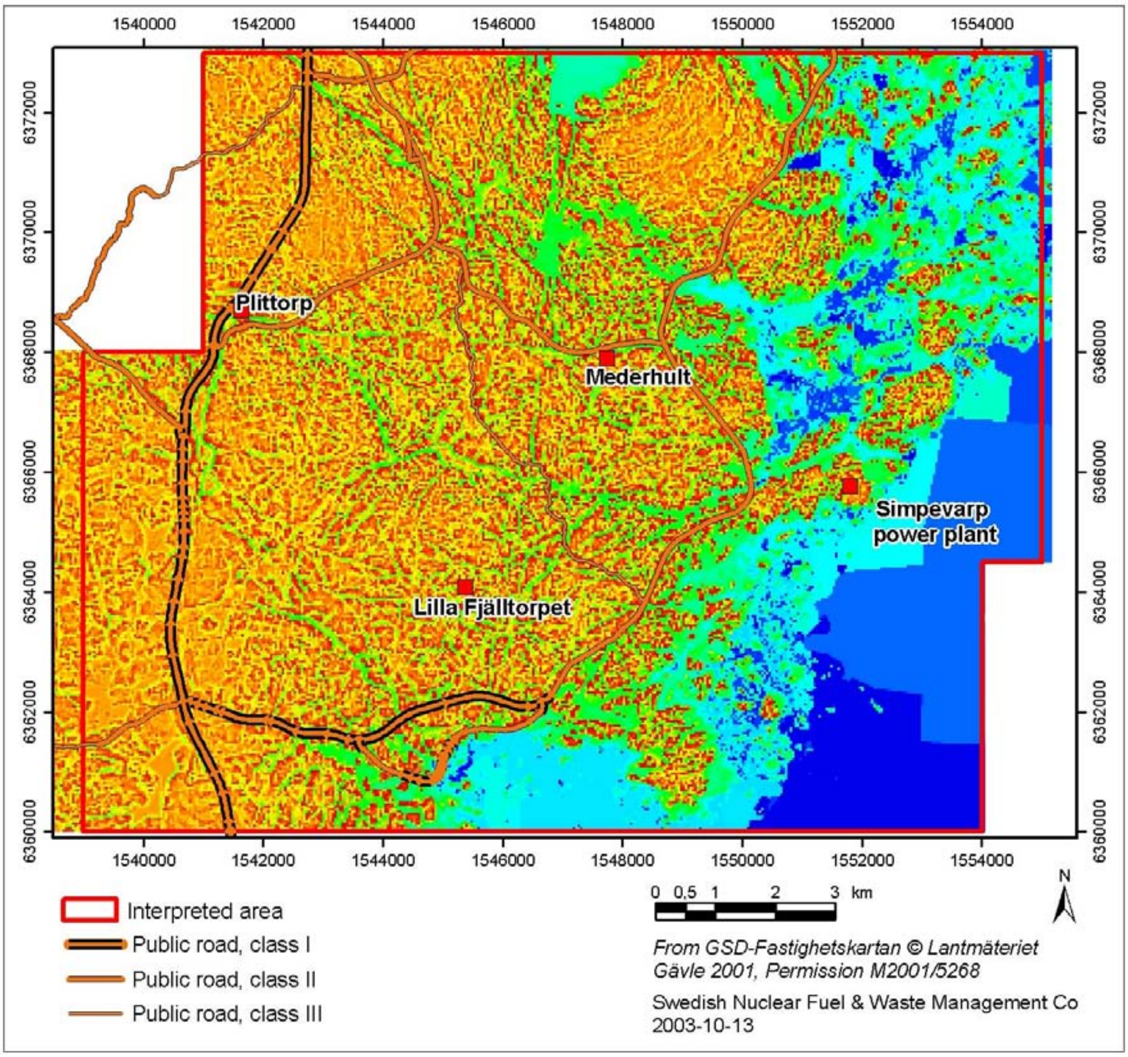

***Figure 4-2**. Simpevarp_höjd_agc_2300m_gridcell10m. The process AGC (Automatic Gain Control) applied to altitude data enhances local variations in altitude. Green and blue colours indicate relative depressions in the terrain relief. The grid files delivered to SKB have a mixture of Swedish and English file names which are also used in this document to avoid confusion.*

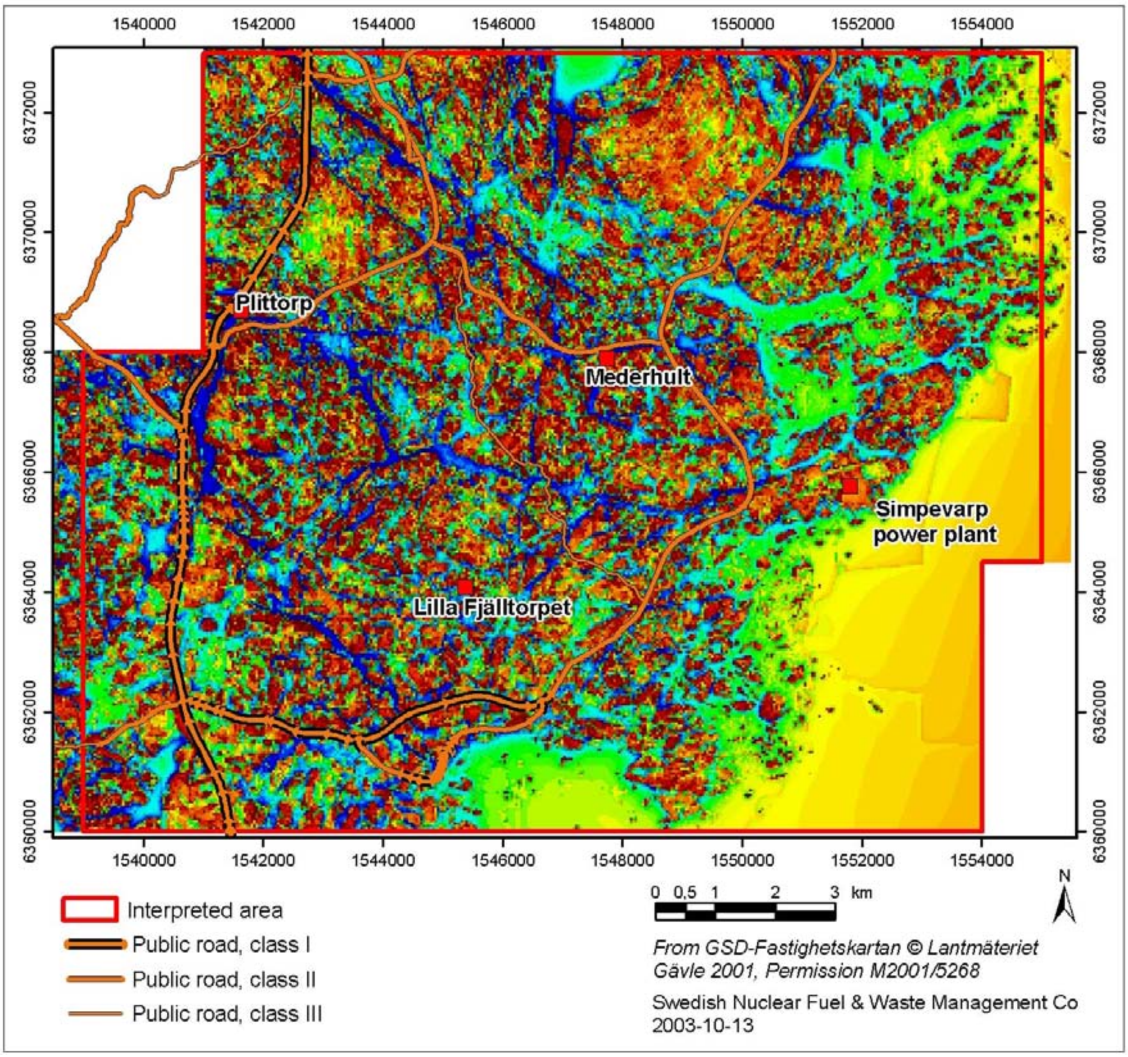

Figure 4-3. *Simpevarp_höjd_hp_005_2300m_gridcell10m. The high-pass filter applied enhances local variations in altitude. Green and blue colours indicate relative depressions in the terrain relief. The grid files delivered to SKB have a mixture of Swedish and English file names which are also used in this document to avoid confusion.*

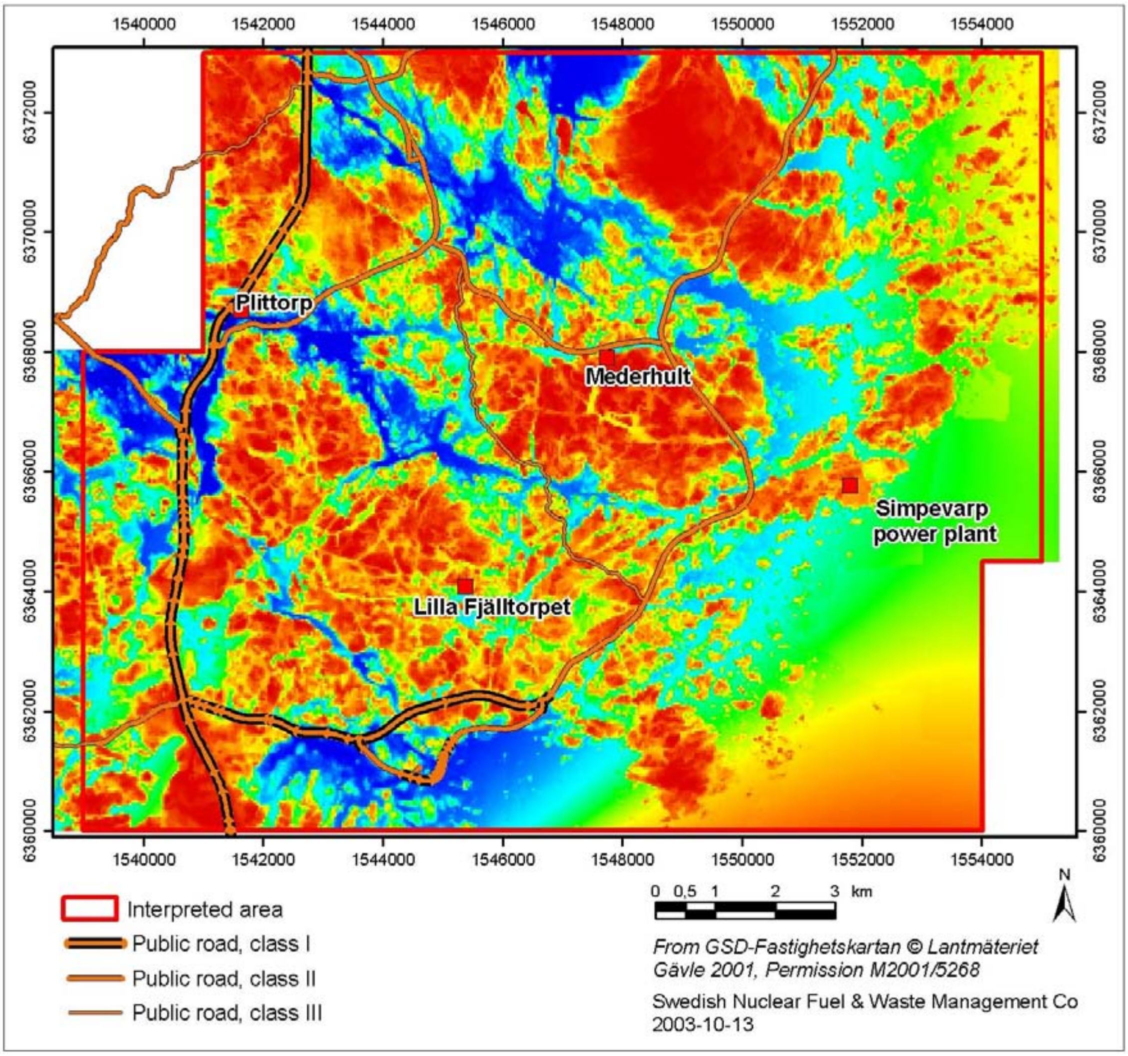

Figure 4-4. *Simpevarp_höjd_trendremoved_2300m_gridcell10m. The removal of a trend enhances local variations in altidtude. Reddish and yellowish colours indicate relative heights. The grid files delivered to SKB have a mixture of Swedish and English file names which are also used in this document to avoid confusion.*

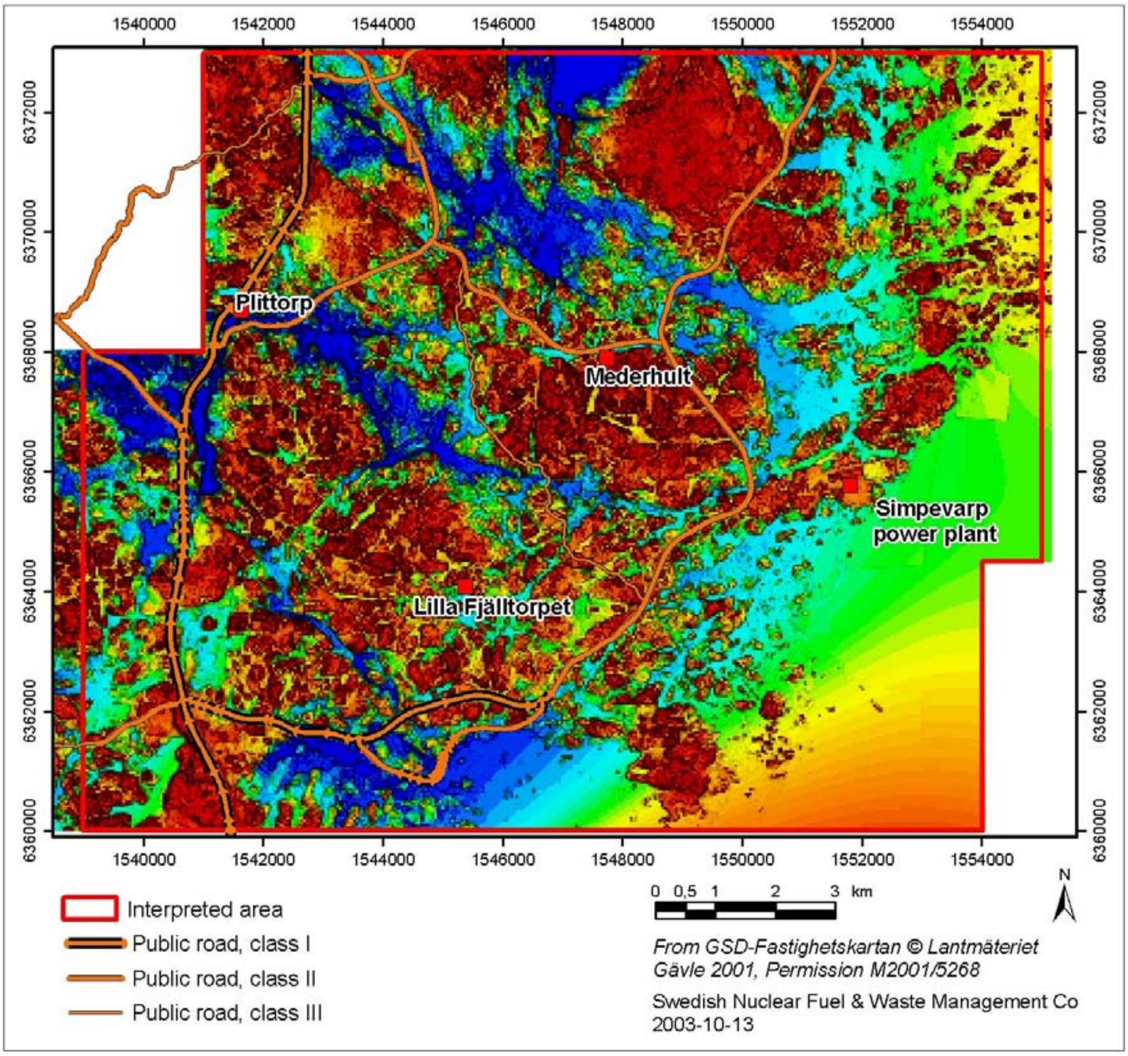

***Figure 4-5**. Simpevarp_höjd_trendremoved_shaded_2300m_gridcell10m. As Figure 4-4 but with vertical light for shading. The grid files delivered to SKB have a mixture of Swedish and English file names which are also used in this document to avoid confusion.*

Other topograpical data used were rectified infrared (IR) photos and ArcView shape files containing the "Fastighetskartan".

The IR-photos were resampled from a grid cell size at the delivery of 0.2 m to 0.8 m. This was done to enhance the performance of the computer system during the interpretation work. This degradation of resolution is not considered to affect the diagnostic level in the identification process. Furthermore the colour scheme of the infra red image was slightly adjusted. An example of the processed infra red image is presented in Figure 4-6.

The "Fastighetskartan" was used without any processing applied.

Figure 4-6. *Example of a processed infra red image. Bluish and greenish tint is found where pine dominates and where the ground is comparatively dry, and brownish tint where the ground is wet or the trees carry leaves.*

4.2 Interpretation

The procedure of the interpretation is described in detail in the method description, here is given a brief outline only.

The interpretation process consists of identifying, drawing and assigning attributes to the individual lineaments in a GIS. The identification is carried out using the five different GIS adapted grids (images) presenting elevation data in different modes (see Section 4.1). Drawing is made with cursor on screen. The assignment of attributes to the lineaments is made according to Table 4-2.

Table 4-2. List of attributes for the individual lineaments.

Name of attribute	Values in this activity (not used is marked by n.a.)	Comment
ID_T	n.a.	Identities have not been assigned to the individual lineaments.
ORIGIN_T	topography	
METHOD_T	DEM grid 10 m	
CHAR_T	n.a.	The character of the lineaments have not been assigned.
UNCERT_T	low, medium, high	Major and local major have been assigned individual values. Local minor have been assigned the value medium by default.
CLASS_T	major, local major, local minor	This classification is mainly based on the total length of the sub-sections constituting a possible system of lineaments. A high degree of personal judgement is introduced when such systems are defined. Threshold values for lengths are major > approx 10 km, local major 1–10 km, local minor < 1 km. In a few cases a pronounced visibility of the lineament has implied a higher rank than would be expected if purely based on length.
COMMENT_T	"esker, hides a deformation zone?" written in Swedish in the attribute list (ås, gömmer zon?)	This attribute has been given a value only in a few cases where the Quaternary geology is suspected to affect the diagnostic level of the identification, i.e. possibly hiding signs of deformed bedrock.
PROCESS_T	image analysis	
DATE_D	20030516 (default)	Date when the last change was made in the individual lineament.
SCALE_T	n.a.	
PLATFORM_T	airphoto 2300 m	The IR images and Fastighetskartan have been left out since they were used only for control.
WIDTH_N	0	Has not been specified.
PRECIS_N	0	Has not been specified.
SIGN_T	CAT/GeoVista	Interpreted by Carl-Axel Triumf, GeoVista AB.

Regarding local depressions only a few of the attributes described above are used according Table 4-3 below.

Table 4-3. List of attributes for the local depressions.

Name of attribute	Values in this activity (not used is marked by n.a.)	Comment
ID_T	n.a.	
ORIGIN_T	topography	
METHOD_T	DEM grid 10 m	
CHAR_T	n.a.	The character of the depressions has not been assigned.
UNCERT_T	n.a.	
CLASS_T	n.a.	
COMMENT_T	n.a.	
PROCESS_T	image analysis	
DATE_D	20030516 (default)	Date when the last change was made in the individual depression.
SCALE_T	n.a.	
PLATFORM_T	airphoto 2300 m	The IR images and Fastighetskartan have been left out since they were used only for control.
WIDTH_N	0	Has not been specified.
PRECIS_N	0	Has not been specified.
SIGN_T	CAT/GeoVista	Interpreted by Carl-Axel Triumf, GeoVista AB.

5 Results

The identification process has resulted in quite a large number of lineaments as presented i Table 5-1. The number of lineaments as expressed in Table 5-1 is however somewhat equivocal, especially regarding the group “major”. One apparently single major lineament may consist of several sub-sections as explained in Figure 5-1. The reason behind the large number of sub-sections used is partly to secure a flexibility for future re-interpretation and classification in connection to joint interpretations with other data, partly due to difficulties in joining the different sub-sections.

Table 5-1. The quantity of identified lineaments.

CLASS_T	Number of lineaments = Number of subsections
major	approx 50
local major	approx 600
local minor	approx 4200

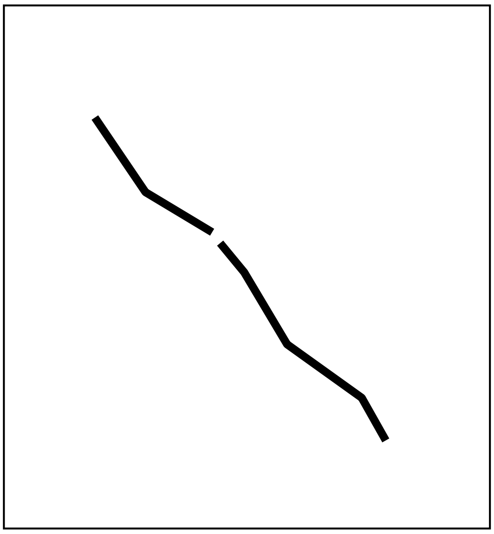

Figure 5-1. *In the drawing above one apparently single lineament consists of two subsections. In the statistics presented in Table 5-1 this example would result in two counts.*

In total the number of delineated depressions is approximately 160 covering around 21 km^2 or 14% of the land covered interpreted area.

The identified lineaments and delineated depressions will be stored in the GIS archive of SKB with field note number *Simpevarp 68*.

Figure 5-2 shows all the identified lineaments and depressions from topographical data. They are displayed only with different line thickness indicating the value of the attribute CLASS_T, major lineaments are displayed with the thickest lines and local minor with the thinnest.

Figure 5-3 shows the major and local major lineaments.

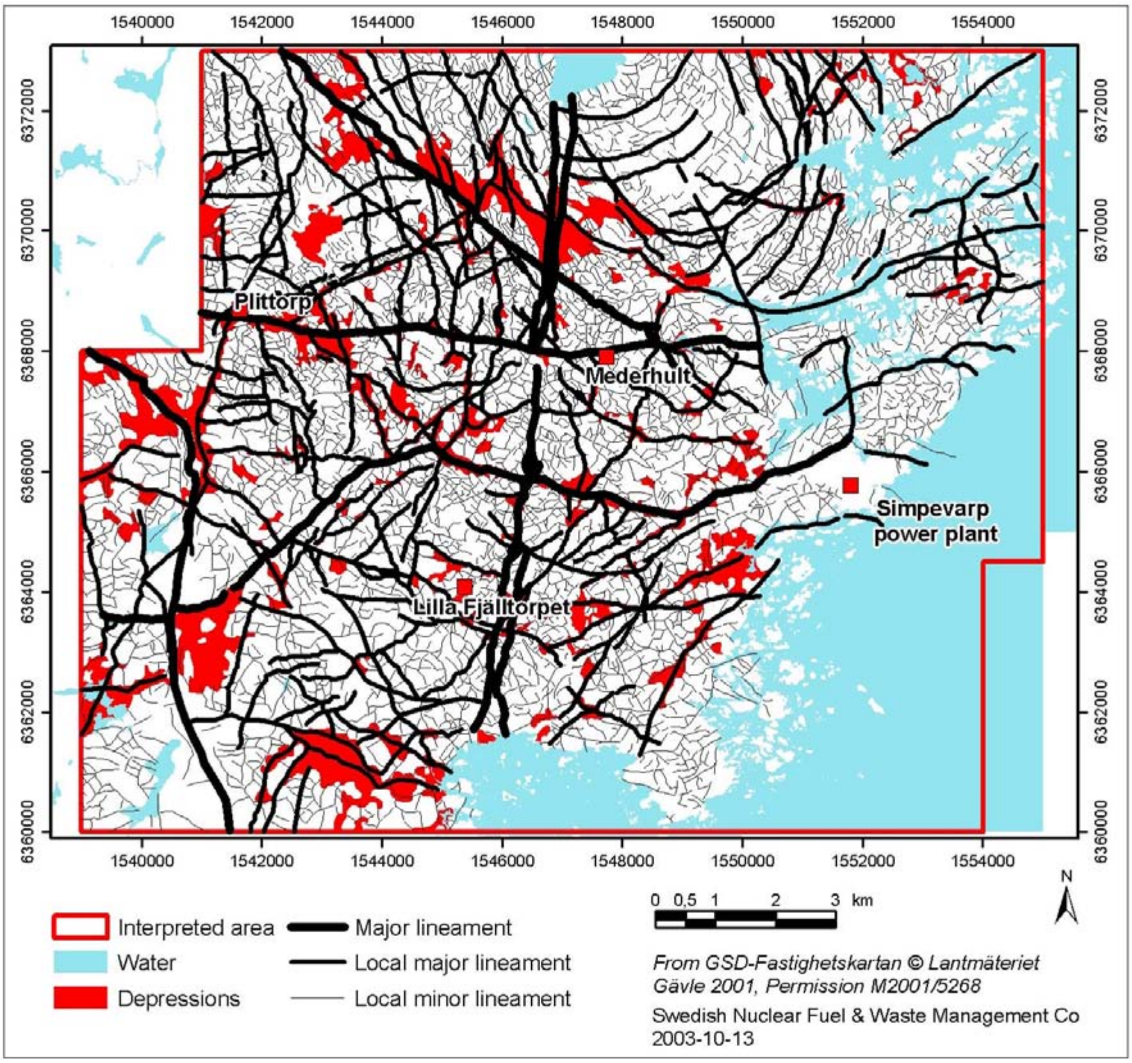

***Figure 5-2**. All lineaments and depressions identified in topographical data.*

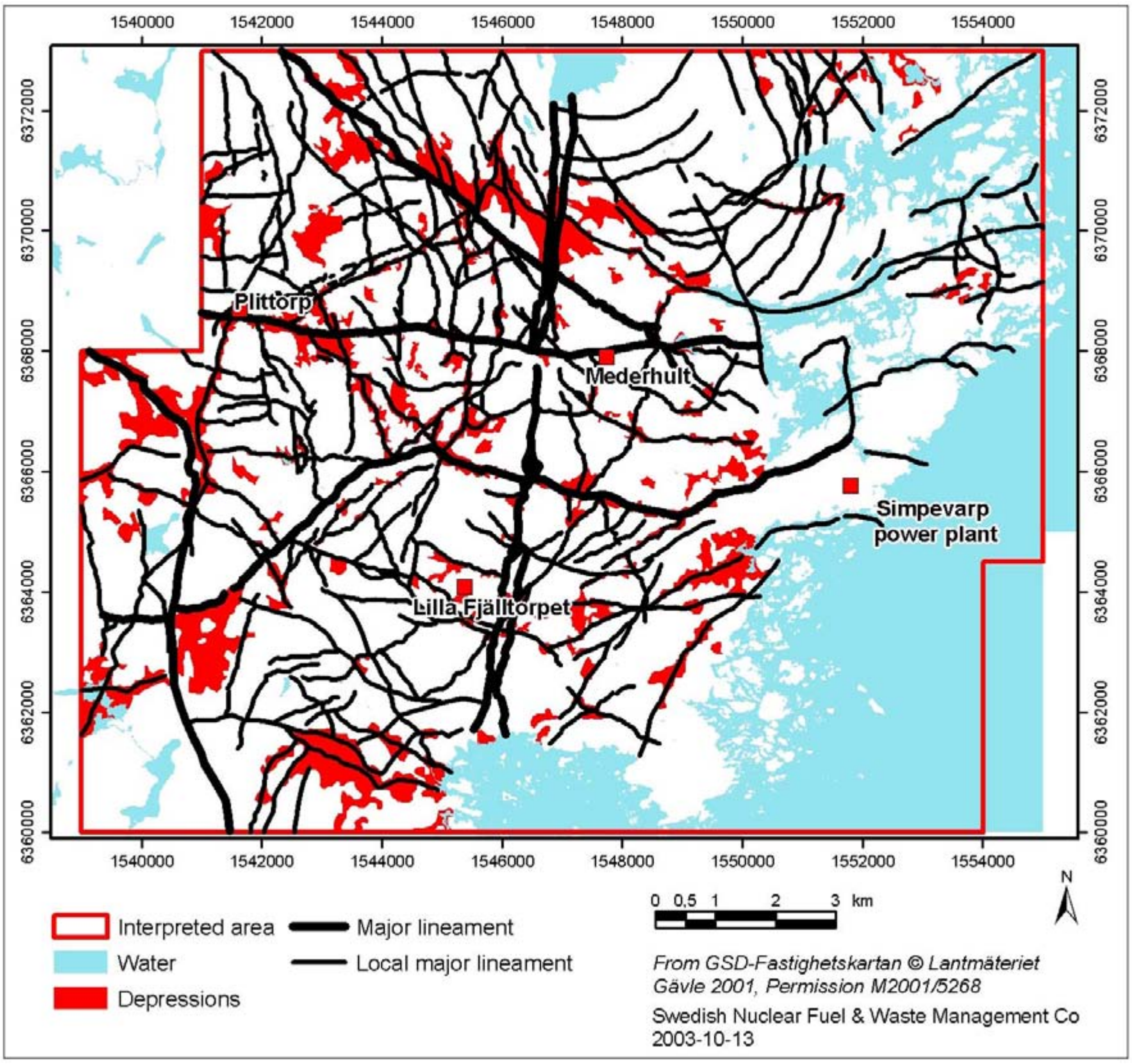

Figure 5-3*. Identified lineaments of class "Major" and "Local major" together with depressions in topography.*

5.1 Discussion

All identified lineaments have, if possible, been assigned attributes of which the attributes CLASS_T and WIDTH_N should give indications of the size of the individual lineament. The attribute WIDTH_N has however not been given any value as the width is difficult to predict. The attribute CLASS_T has however been assigned one of the three values "Major", "Local major" or "Local minor" based on the estimated total length of the lineament, including all sub-sections forming the lineament (see section 5). It is however difficult in many cases to judge whether an identified lineament forms a sub-section to a longer lineament or if it should be considered as an individual lineament.

Areas forming local depressions on the interpretation map are very often covered by Quaternary sedimentary deposits which obscure the topography of the bedrock surface. In many of these depressions deformation zones could be expected to occur since the morphology, besides other factors, reflects the weathering resistance of the bedrock. In the rocks prevalent in the Simpevarp area increased fracturing most certainly reduces the weathering resistance. Within these depressions it is thus difficult to accurately draw a single lineament, and here the level of uncertainty is often high regarding existence and assignment of attributes to single lineaments.

In some areas accumulated Quaternary deposits, such as eskers, occur. In spite of their ridge-like appearance, it can not be excluded that they hide topographic depressions in the bedrock surface. In the western part of the interpreted area there is an esker passing from north to south. It is classified as a lineament on the map however with a comment in the list of attributes.

The identification of lineaments is rather a time consuming procedure. As described in Table 5-1 above in total almost 5000 sub-sections have been delineated. This is of course demanding when it comes to conserving the objectivity throughout the entire interpretation process. The risk of loosing the objectivity has been minimised by a continuous change between sub-areas of interpretation. By this an almost parallel development of the entire area has been achieved and hopefully the problem of introducing a subjectivity varying from day to day has diminished.

6 References

/1/ **SKB, 2002.** Simpevarp – site descriptive model version 0. SKB R-02-35, Svensk Kärnbränslehantering AB.

/2/ **Wiklund S, 2002.** Digitala ortofoton och höjdmodeller. Redovisning av metodik för platsundersökningsområdena Oskarshamn och Forsmark samt förstudieområdet Tierp Norra. SKB P-02-02.