TEST FIELD FOR AERIAL PHOTOGRAPHY

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ABSTRACT

A test field for testing the quality of aerial photography was constructed by the Finnish Geodetic Institute at the Metsähovi Research Station near Helsinki. The field was constructed by using different types of gravel which allows the field to be used over several years for research and regular quality testing purposes with minimum maintenance. The contrasts of the test figures vary from 3:1 to 8:1 and images from 1:3000 to 1:100000 can be tested. Ground control points are available for testing the geometric quality of the photographs. The field is best suited for aerial photography in scale 1:3000.

1. INTRODUCTION

Test fields for testing the quality of aerial photographs and imaging systems have usually been made by painting figures on different kinds of movable plates or on asphalt. These solutions are good if the fields are used only temporarily or for short periods, in generally good weather conditions. If the test field is to be used over the whole summer or several years, painting is not necessarily the only nor the best solution for constructing the field. Wind, rain and frost can cause damages to the field and change the spectral characteristics of the figures.

In 1992 the Finnish Geodetic Institute started to construct a test field for aerial photography at the Metsähovi Research Station near Helsinki and Helsinki-Vantaa airport. The aim was to construct a field which could be used all year round for many years with little maintenance. The field can be used by private companies and governmental agencies that would like to test the quality of their aerial imaging systems whenever the weather is suitable for imaging. For this reason different types of gravel were selected as material for the test field.

The main construction principles were the following:

a) To use materials which will not be damaged by rain.

b) To use contrasts which are close to those of the real world in the test figures.

c) To use figures that allow the testing of image quality for all types of airborne sensors.

d) To enable temporary testing.

e) To test the geometric accuracy of imaging systems.

The field was ready for regular use in the summer 1994.

2. THE STRUCTURE OF THE FIELD

2.1 Construction of the field

The test field covers an area of about 6000 m^2 and it is located in a rural area surrounded by fields, forests and lakes. It was constructed on field and consists of the following layers from bottom to top: clay, sand, fiber material, gravel (diameter from 25-55 mm), fiber material, gravel (diameter 8 - 16 mm or 4 - 8 mm). This construction and these materials together with proper drainage prevent water puddles even during the heaviest rainfalls. The surface of the field is dry very soon after a rainfall. Different types of gravel, sand and grass are used in the test figures. Figure 1 shows the cross section of the test field.

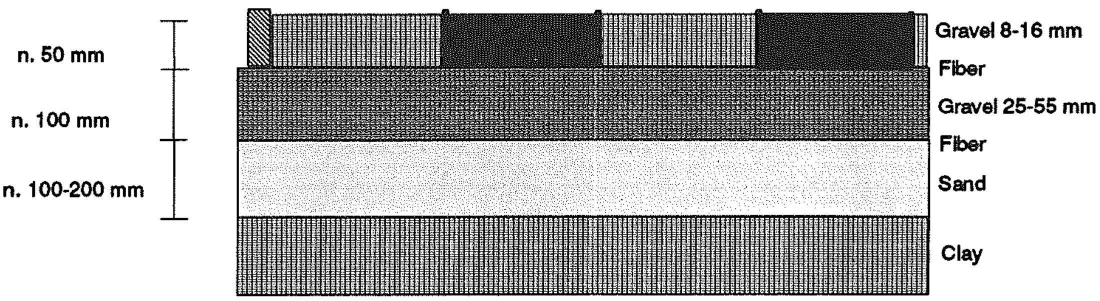

Figure 1. The different layers of the test field.

2.2 Materials and their spectral characteristics

The top layers of the test field are the following: dark gabbro, grey granite, red granite, limestone, sand and clay/grass. The spectral reflectances of these layers, except grass, were measured by using a spectroradiometer. The spectral reflectance was measured in 4 nm steps in the range of 390 - 900 nm. The results of these measurements are presented in figures 2 - 6.

As can be seen only dark gabbro and grey granite give almost even reflectances in all wave-lengths. The differences between maximum and minimum reflectances are caused by the small aperture of the spectrometer and the short measurement distances (about 5 meters) compared with the size of the gravel. Even the limestone does not have an even reflectance. It was selected because it produced useful contrasts in the test figures. Red granite was selected because it gives varying contrasts in different parts of the spectrum. The reflectances of sand and red gravel are close to each other but gravel was selected because it is much easier to use in test fields and dries much faster than wet sand.

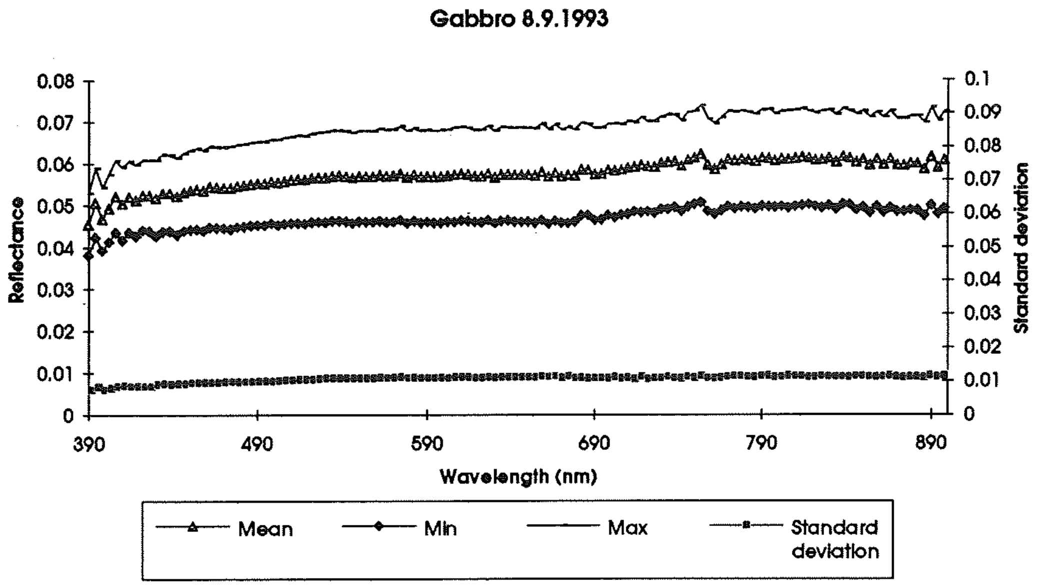

Figure 2. The reflectance of Gabbro. A different scale for the standard deviation is given on the right hand side.

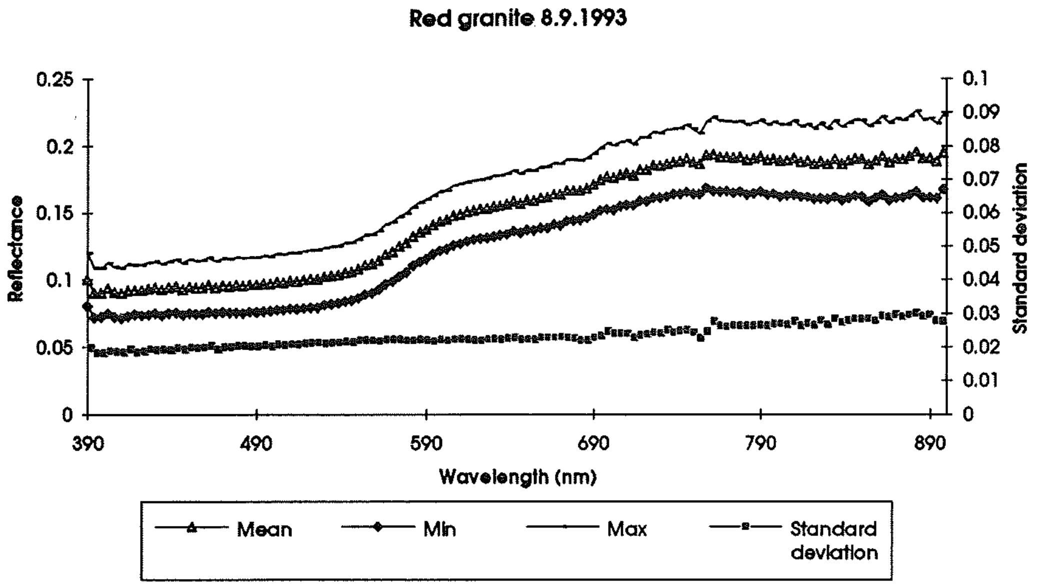

Figure 3. The reflectance of Red granite. A different scale for the standard deviation is given on the right hand side.

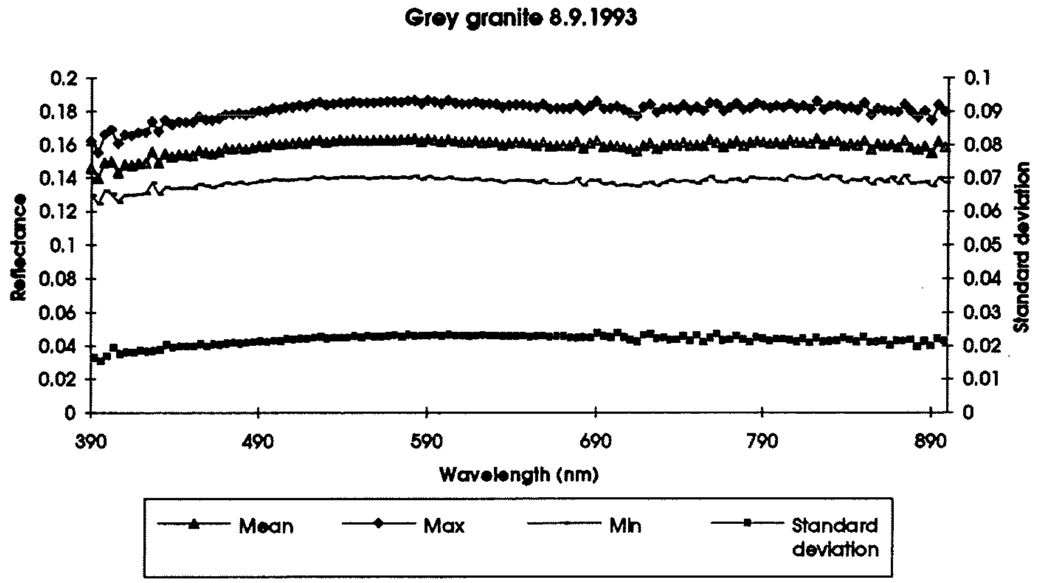

Figure 4. The reflectance of Grey granite. A different scale for the standard deviation is given on the right hand side.

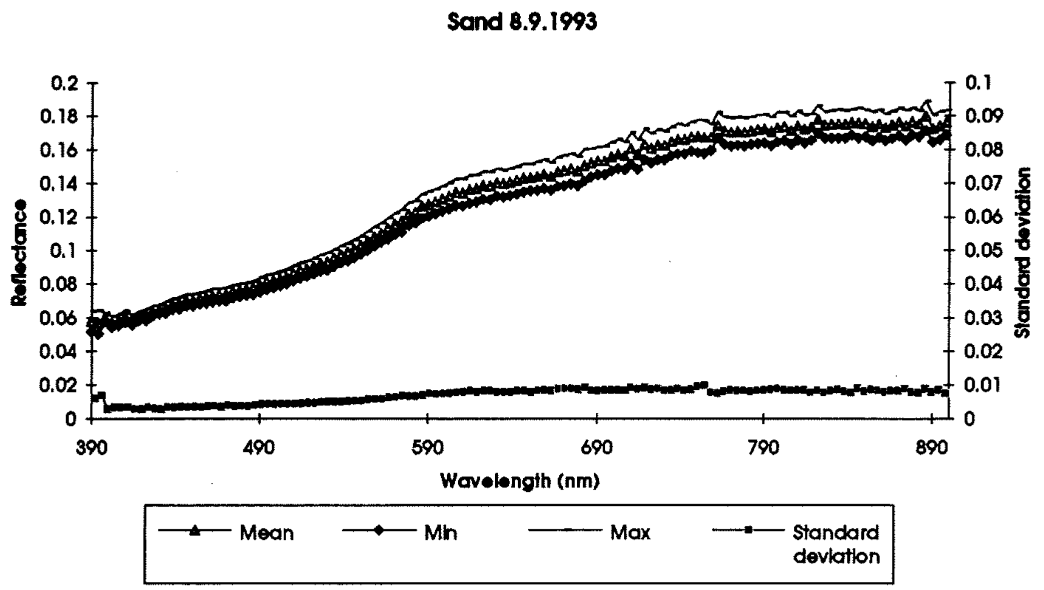

Figure 5. The reflectance of Sand. A different scale for the standard deviation is given on the right hand side.

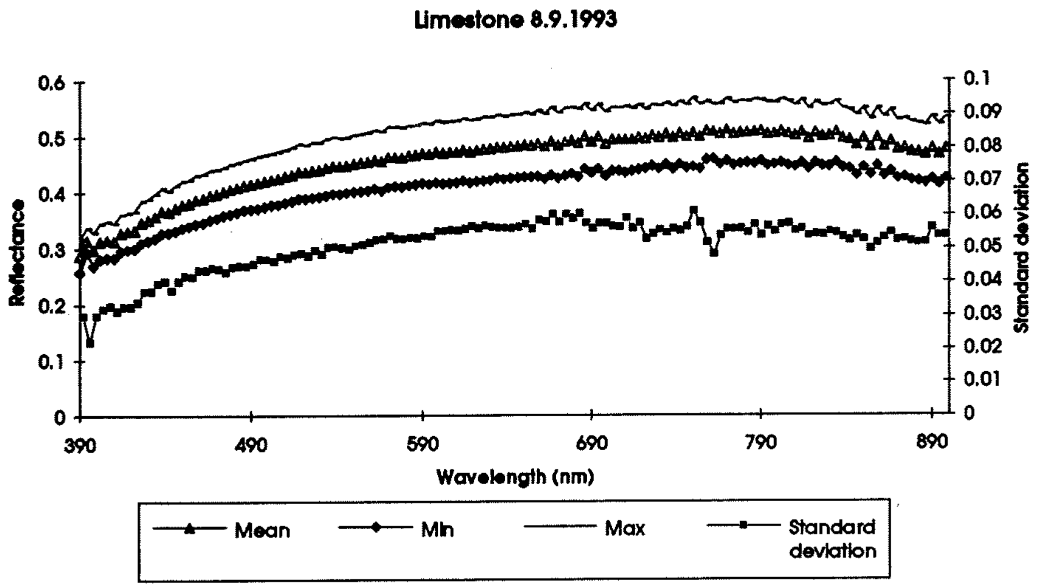

Figure 6. The reflectance of Limestone. A different scale for the standard deviation is given on the right hand side.

Figures 7 - 9 show the modulations of different materials in different wavelength ranges. Gabbro, grey granite and limestone gave modulations which are relatively even throughout the whole range of the spectrum, and these materials were selected when bar-targets were constructed. The average contrasts of these three materials were:

Limestone/dark gabbro	8:1
Limestone/grey granite	3:1
Grey granite/dark gabbro	3:1

The effect of rain on the reflectances of different types of gravel was tested by measuring the reflectance of wet and dry samples. Wet surfaces decreased the reflectances by 55 % for dark gabbro and grey granite whereas the reflectance of the limestone did not change at all. The reflectance of the red granite decreased by 30 %. Thus limestone gives a good reference if the field is wet when imaged.

2.3 The effect of the gravel size on the reflectances

The size of a piece of gravel should be such that it gives a Lambertian reflectance for the test figures. This means that there must be several pieces of gravel in a test figure. When selecting the size of the gravel one has to pay attention to the scale of the imagery as well as the size of the detector or the granularity of the film. The surface of a piece of gravel is rough and reflects light in many directions. The measurements of gravel reflectance from an area containing 1 - 5 gravel pieces showed that the variation of reflectance due to the different gravel pieces was 10 - 20 % on average. Thus by using gravel, the image of a piece of gravel on the focal plane will be equal or smaller than the size of a single detector or film grain, and we can obtain images where image noise is mainly dependent on the image itself. Thus we decided to use two gravel sizes; 4 - 8 mm and 8 - 16 mm in the test figures. This allows measurements up to the scale 1:3000, because then the number of grains per one bar is about 800 in the smallest bars. Figure 10 and 11 show some microdensitometer measurements of the test figures from photos taken in scale 1:4000. The width of the slit was 5 micrometers.

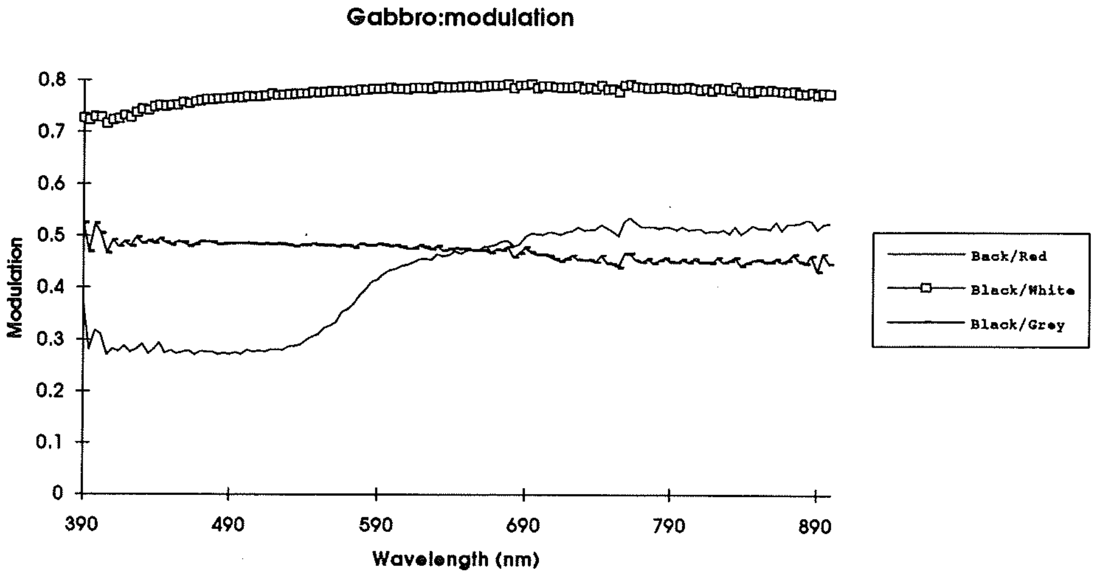

Figure 7. Modulation of Gabbro.

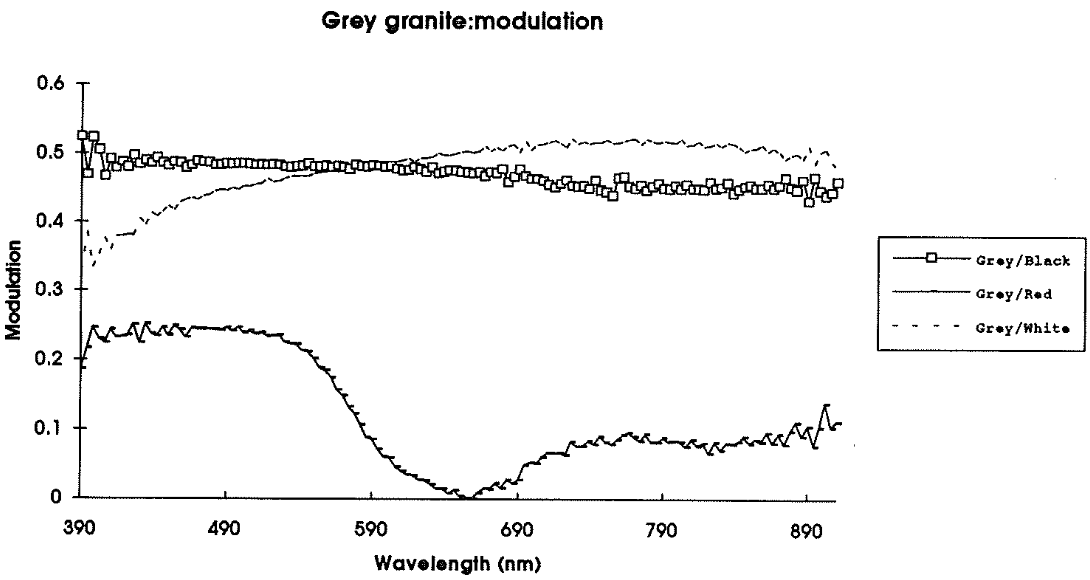

Figure 8. Modulation of Grey granite.

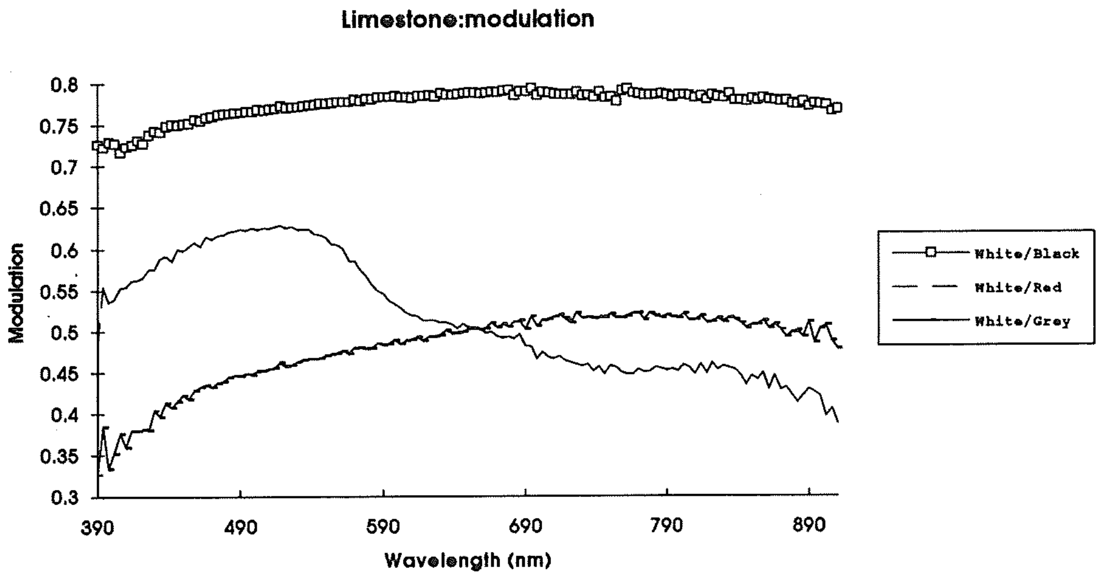

Figure 9. Modulation of Limestone.

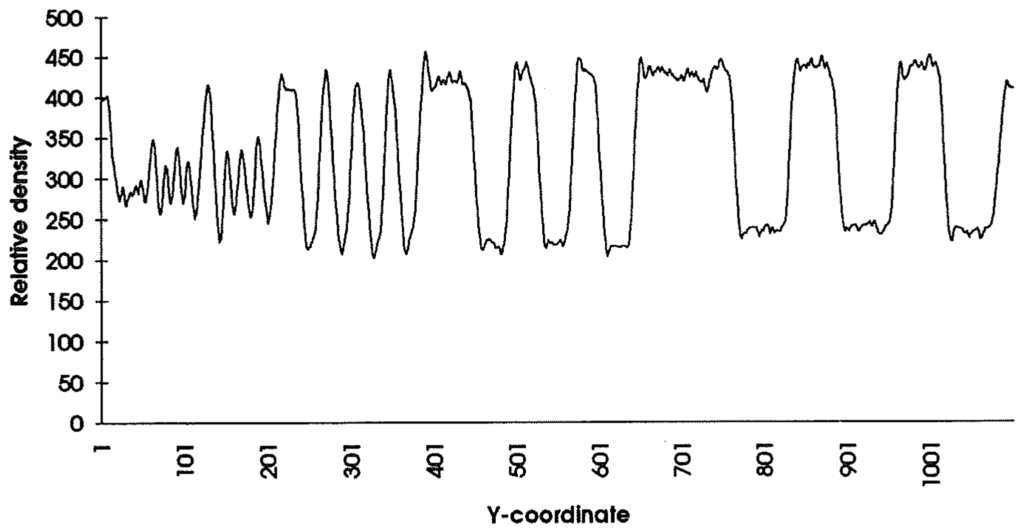

Figure 10. Microdensitometer measurements of grey granite/dark gabbro test-bar targets. The width of the bars varies from 3 to 125 cm. The scale of the measured photo was 1:4000.

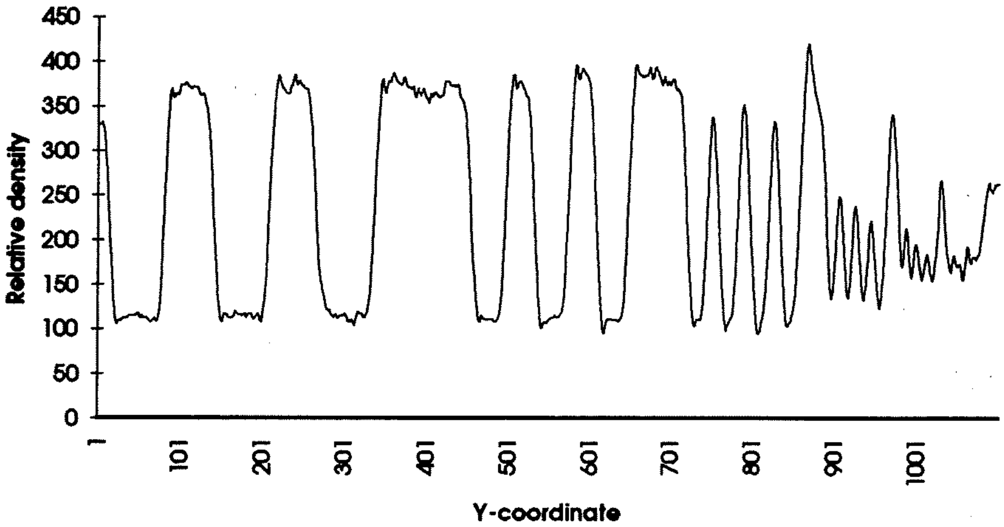

Figure 11. Microdensitometer measurements of limestone/dark gabbro test-bar targets. The width of the bars varies from 125 cm to 3 cm. The scale of the photo was 1:4000.

3. TEST FIGURES AND GROUND CONTROL POINTS

3.1 Test figures

The test field can be used for testing photographs in scales from 1:3000 to 1:100000, but the most accurate test figures are made for the scale of 1:3000. This was selected because it is commonly used in Finland for large scale mapping purposes. A map of the test field is shown in figure 12. The field consists of the following parts:

a) Bar-target figures made from dark gabbro, grey granite and limestone for the determination of the spatial resolution. The background is dark gabbro. The width of the bars varies from 3 cm to 150 cm. There are altogether 8 groups of bars each having 3 or 4 bars. For the photographs in scale 1:3000 there are altogether 13 groups of bars and the width of the bars varies from 3 cm to 12 cm. The bar width ratio is $\sqrt[5]{2}$.

b) Large rectangular areas ($15*7m^2$) made from dark gabbro, grey granite, red granite, limestone, sand and clay/grass for contrast attenuation studies and for determination of the spatial resolution of images. The background is made of dark gabbro.

c) Round shaped figures made from dark gabbro and limestone for determination of the spatial resolution of images. The background is made of grey granite.

d) A grey scale of nine steps made from dark gabbro and limestone by proper mixing of these materials. This can be used for studying the radiometric resolution and exposure checking.

Half of the test field is covered exclusively by dark gabbro which allows the use of transportable targets for temporary tests.

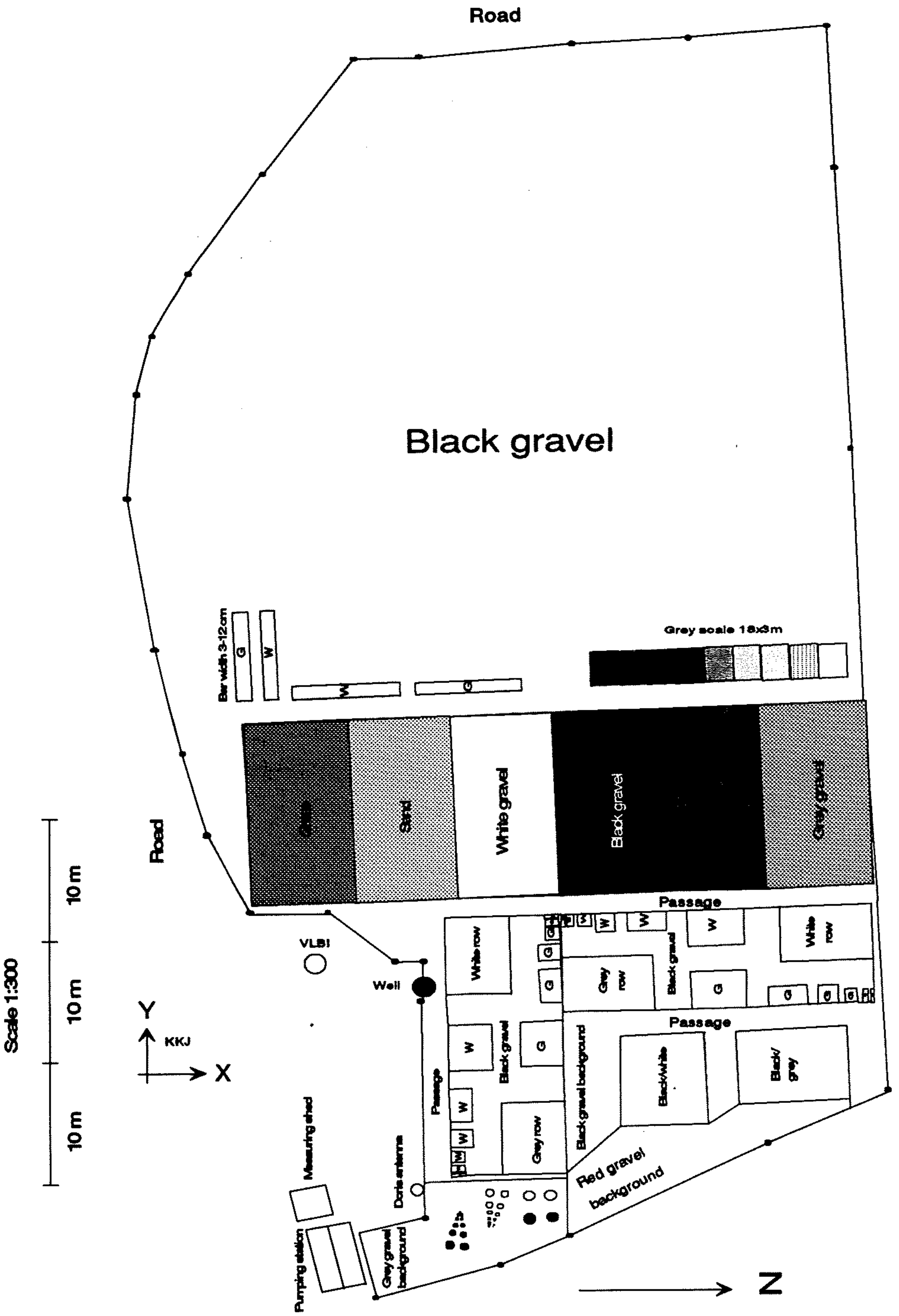

Figure 12. The Sjökulla test field.

The field was photographed in the summer 1993 and 1994 in scales of 1:3000, 1:4000, 1:20000, 1:30000 and 1:60000. These images showed that the field works well, which was proved by the low noise of the figures in the image.

3.2 Ground control points

The test field is surrounded by a ground control point network of 47 points which was set up and measured using GPS in spring 1994. 17 of these points are fixed in bedrock or big stones whereas the rest of the points are fixed in soil only. For this reason it is necessary to measure the coordinates of these points each spring after the frost layer has melted. The points will be marked by round-shaped white signals having the diameter of 30 cm. The background of the signal is black. The network is used for testing the geometric accuracy of imaging systems. The test can be made at the same time as the quality test if the images are tested by using the test figures.

4. DISCUSSION

The usefulness of test fields are widely known and demonstrated. When a field is made of gravel some problems may arise due to the aging. The most problematic ones are in this case the following:

- The change of the reflectivity of the gravel due to dust, lichen and moss. The dust is mainly removed by rain but lichen and moss can be a problem in coming years. The lichen and moss problem maybe avoided by mixing the surface of the gravel and/or transporting new gravel but in all cases annual measurement of reflectance is needed for testing the stability of the reflectance.

- Frost in winter can damage the field by moving the gravel and thus changing the dimensions of the figures. The experience from winter 1993/1994 showed that this may not be a serious problem but damage can occur in hard winters. The aerial photos show that the reflectance of the gravel may be dependent on the direction of the sun and the measurement. Thus in future measurements will be carried out to determine the bi-directional reflectance distribution function.

The future use of the test field will show how well it works in practice. The aim is that it can be used for regular tests and for research purposes.