# DigiMeyer

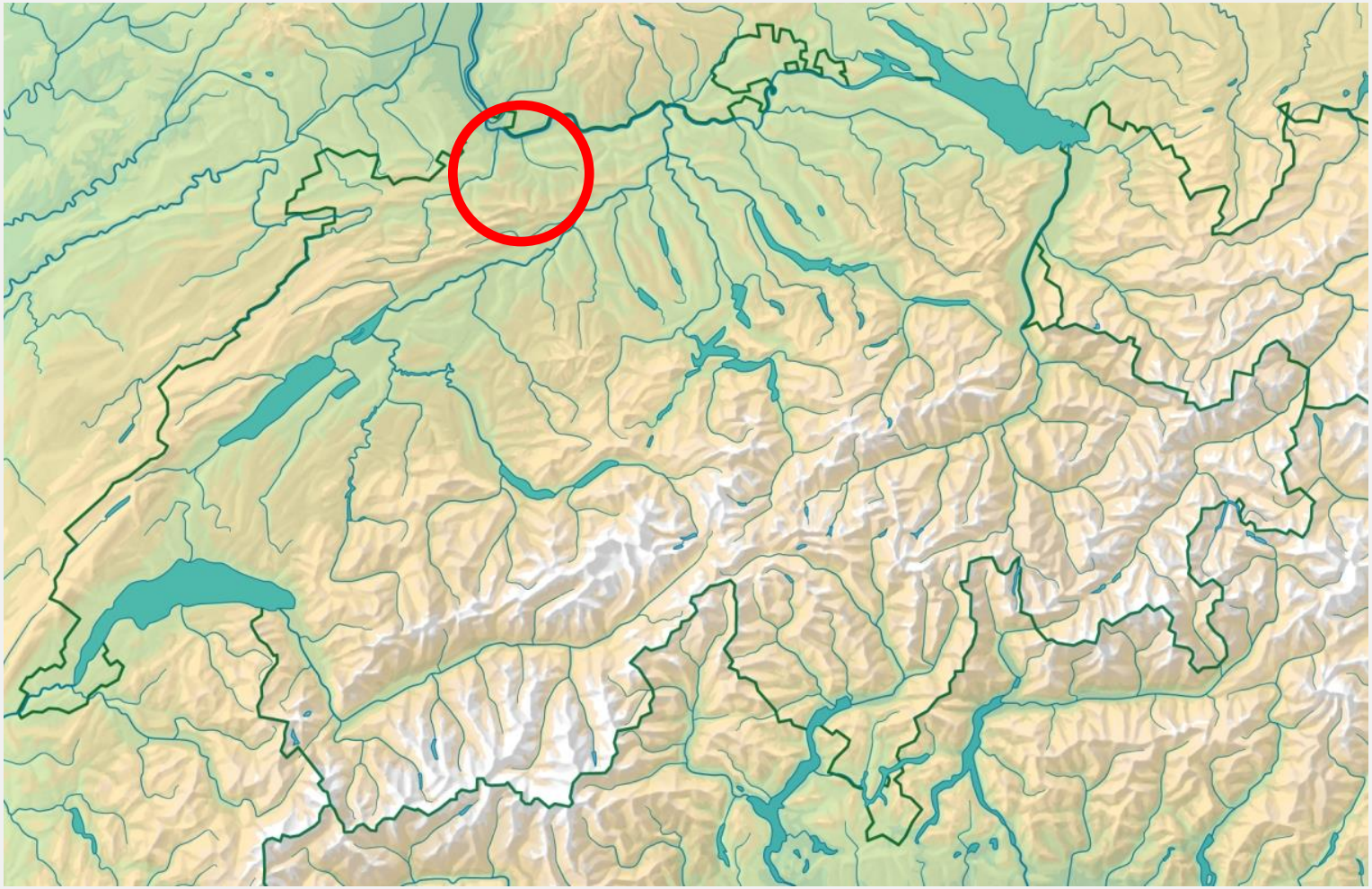
A digitizing project for the large-size map of the territory of Basel from the 1680s

Martin Rickenbacher, Berne (Switzerland)

# Items

- The territory of Basel and the map(s)
- The map‘s author: Georg Friedrich Meyer
- Why should this map be digitized?
- The digitizing process
- How accurate is the map?
- Open questions
- Conclusions

# The territory of Basel



Übersichtskarte 1:2Mio © swisstopo



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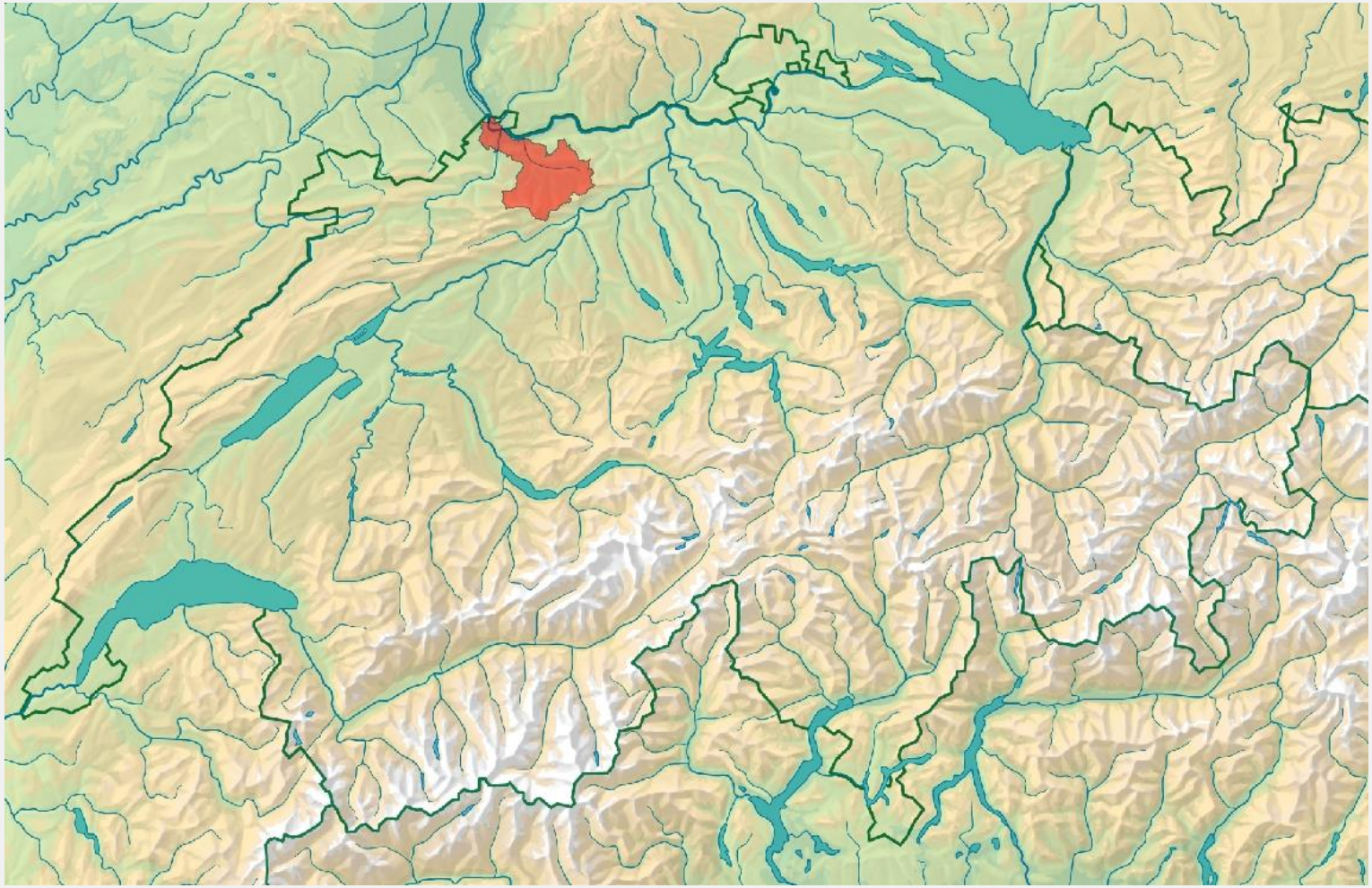
# The territory of Basel



Übersichtskarte 1:2Mio © swisstopo



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# Basel and maps

- Around 1500: Basel was one of the leading centers of early book production in Central Europe
- Geographical publications with numerous maps
- E.g. 1544 Sebastian Münster‘s «Kosmographey»
- 1538 first regional map of the territory of Basel
- One of the oldest regional maps of Switzerland
- In the late 16$^{th}$ century Basel had therefore already a long tradition in maps and map making



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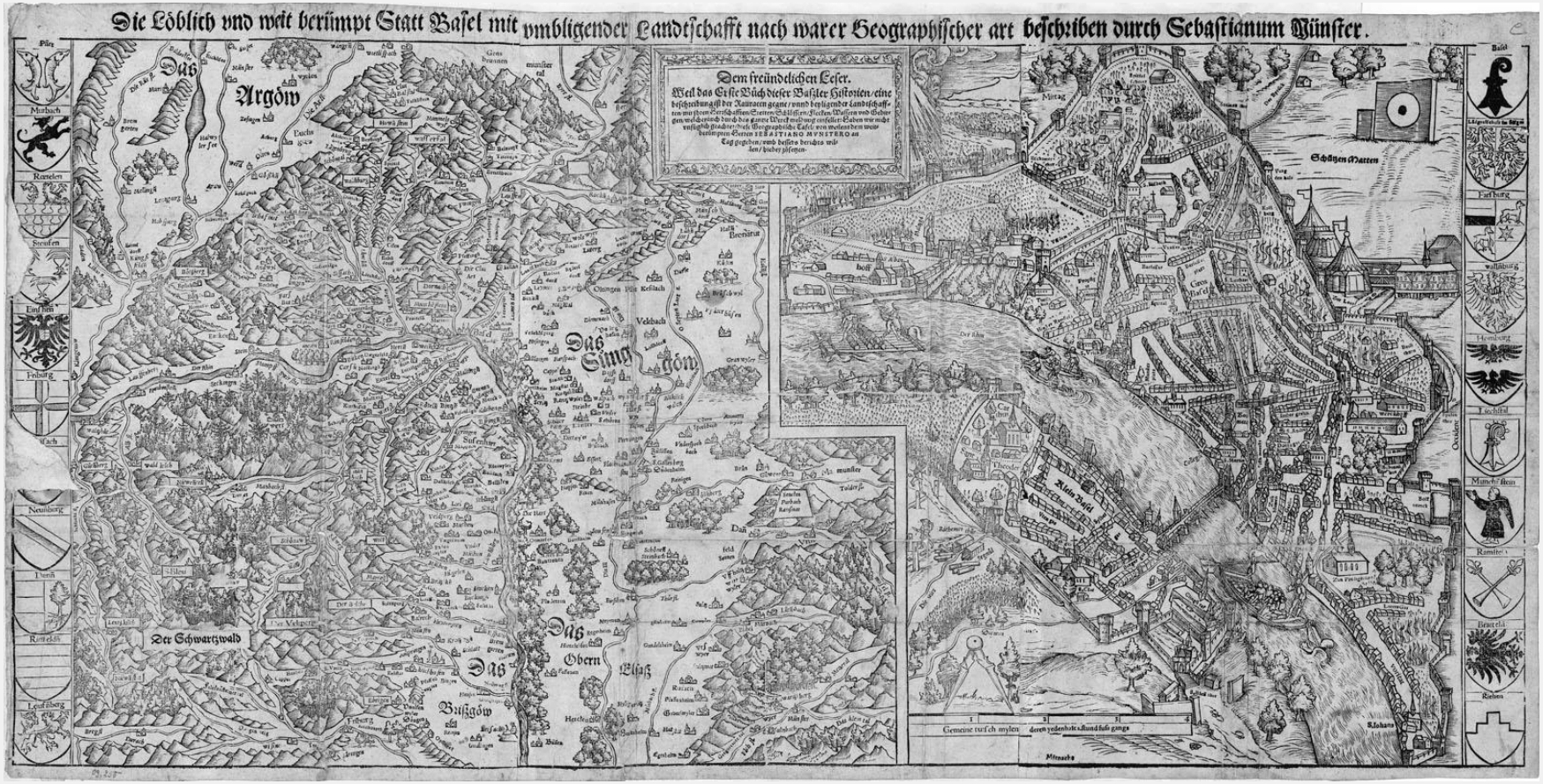
# Basel and maps




Sebastian Münster 1538 (1580) © swisstopo Kartenarchiv LT K Ba 29



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# First surveys of Basel

- 1588: The painter Hans Bock the Elder receives 40 florins for his ground view of the town
- In the following decades, he surveys a lot of plans for the boundaries of the canton
- Assisted by his sons Hans and Niklaus
- Some of these plans are kept at the State Archives of Basel-Stadt and Basel-Landschaft
- These Archives are divided due to the revolutionary separation war from 1830 – 1833



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# Jacob and Georg Friedrich Meyer

- «Lohnherren» (officials, town engineers)
- Jacob Meyer 1614 – 1676 (father)
- Georg Friedrich Meyer 1645 – 1693 (son)
- Well educated in mathematics, surveying and fortification
- Area of operation not only in the territory of Basel, but also in Alsace and Lorraine
- Authors of various small textbooks

# Meyer`s small textbooks

Stadt- und Universitätsbibliothek Bern (StUB)

Compendium Arithmeticae Germanicae (J.M. 1665)

Arithmetica Decimalis (J.M. 1669)

Doctrina Triangulorum (G.F.M. 1678)

Geometria Theoretica (J. [G.F.]M. 1691)

Compendium Geometriae Practicae (J.M. 1663)

Stereometria (G.F.M. 1691)

Arithmetica Practica (J.M. 1665)



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# Compendium Geometriae Practicae


Compendium Geometriæ Practicæ,
sive,
PLANIMETRIA,
Kurtzer Bericht/
vom Feldmessen
und Feld = theilen.
Durch
Jacob Meyern/ Lohnherren in Basel.
Basel/ gedruckt und verlegt bey Johann Ludwig König
und Johann Brandmyller. 1684.
H. VIII. 595
(5)
Stadt- und Universitätsbibliothek Bern (StUB) H.VIII.595 (5)

First edition 1663



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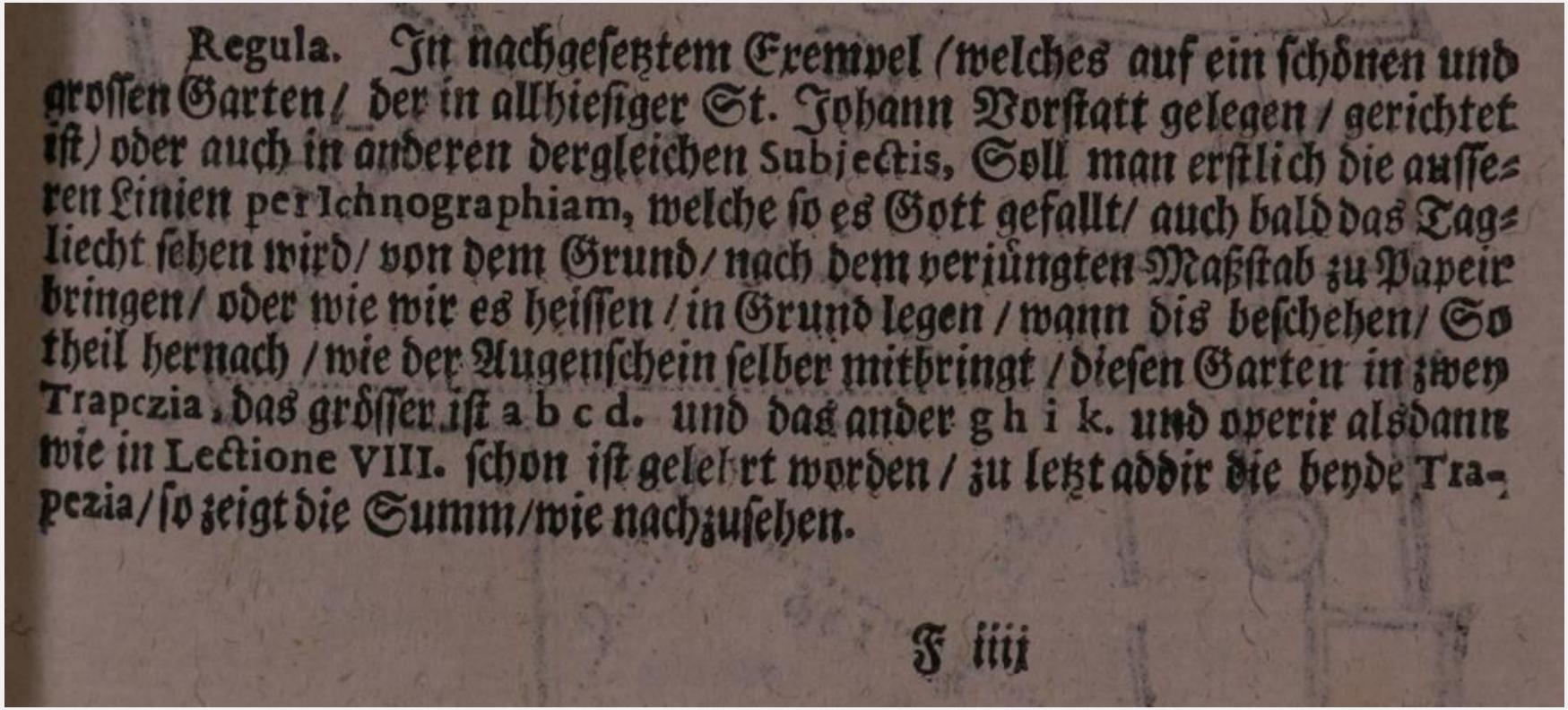
# Compendium Geometriae Practicae



Regula. In nachgesetztem Exempel (welches auf ein schönen und grossen Garten / der in allhiesiger St. Johann Vorstatt gelegen / gerichtet ist) oder auch in anderen dergleichen Subjectis, Soll man erstlich die aussern Linien per Ichnographiam, welche so es Gott gefallt / auch bald das Tagliecht sehen wird / von dem Grund / nach dem verjüngten Maßstab zu Papeir bringen / oder wie wir es heissen / in Grund legen / wann dis beschehen / So theil hernach / wie der Augenschein selber mithringt / diesen Garten in zwey Trapezia, das gröſſer ist a b c d. und das ander g h i k. und operir alsdann wie in Lectione VIII. schon ist gelehrt worden / zu letzt addir die beyde Trapezia / so zeigt die Summ / wie nachzusehen.

F iiij

Stadt- und Universitätsbibliothek Bern (StUB) H.VIII.595 (5) p. 87

Surveying a large garden in Basel



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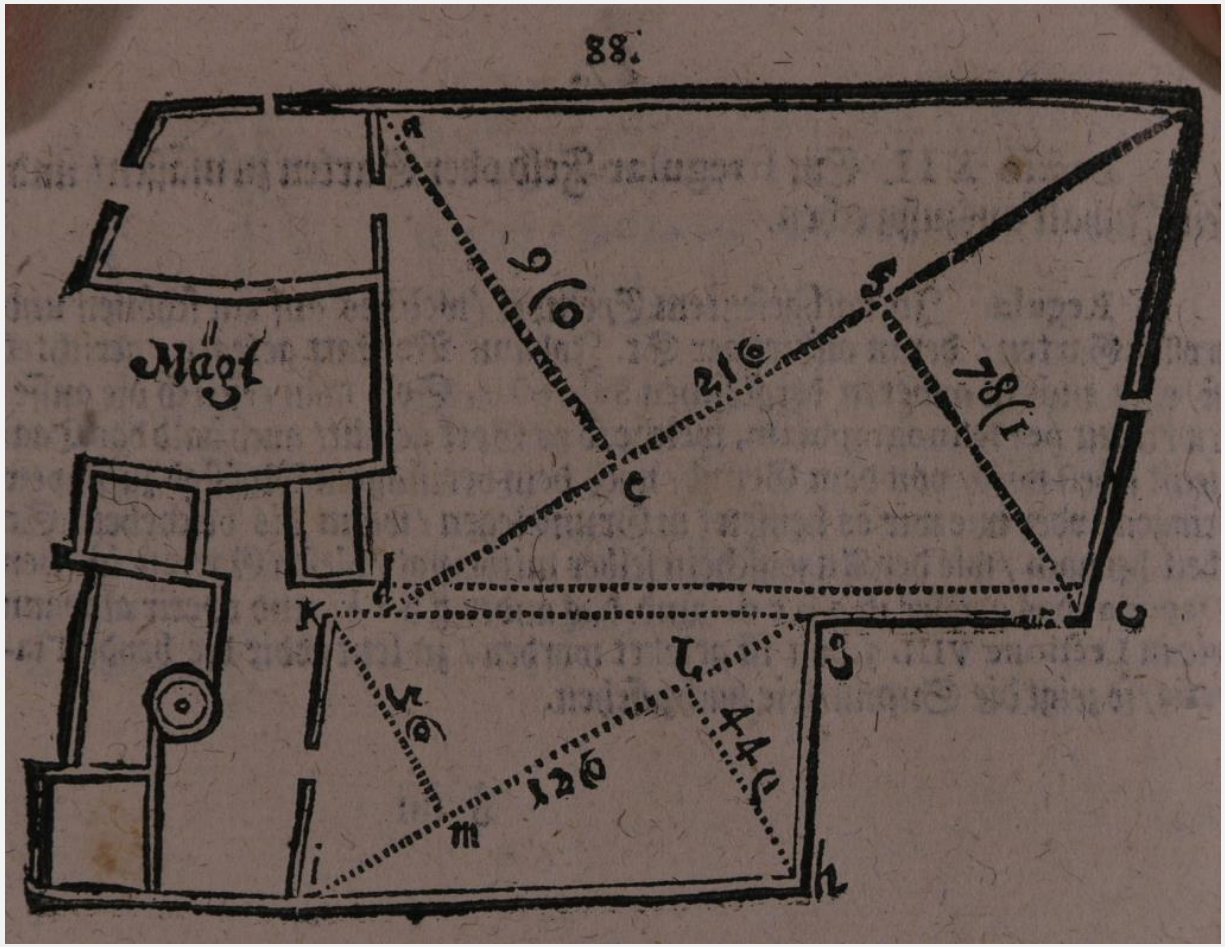
# Compendium Geometriae Practicae




Stadt- und Universitätsbibliothek Bern (StUB) H.VIII.595 (5) p. 88



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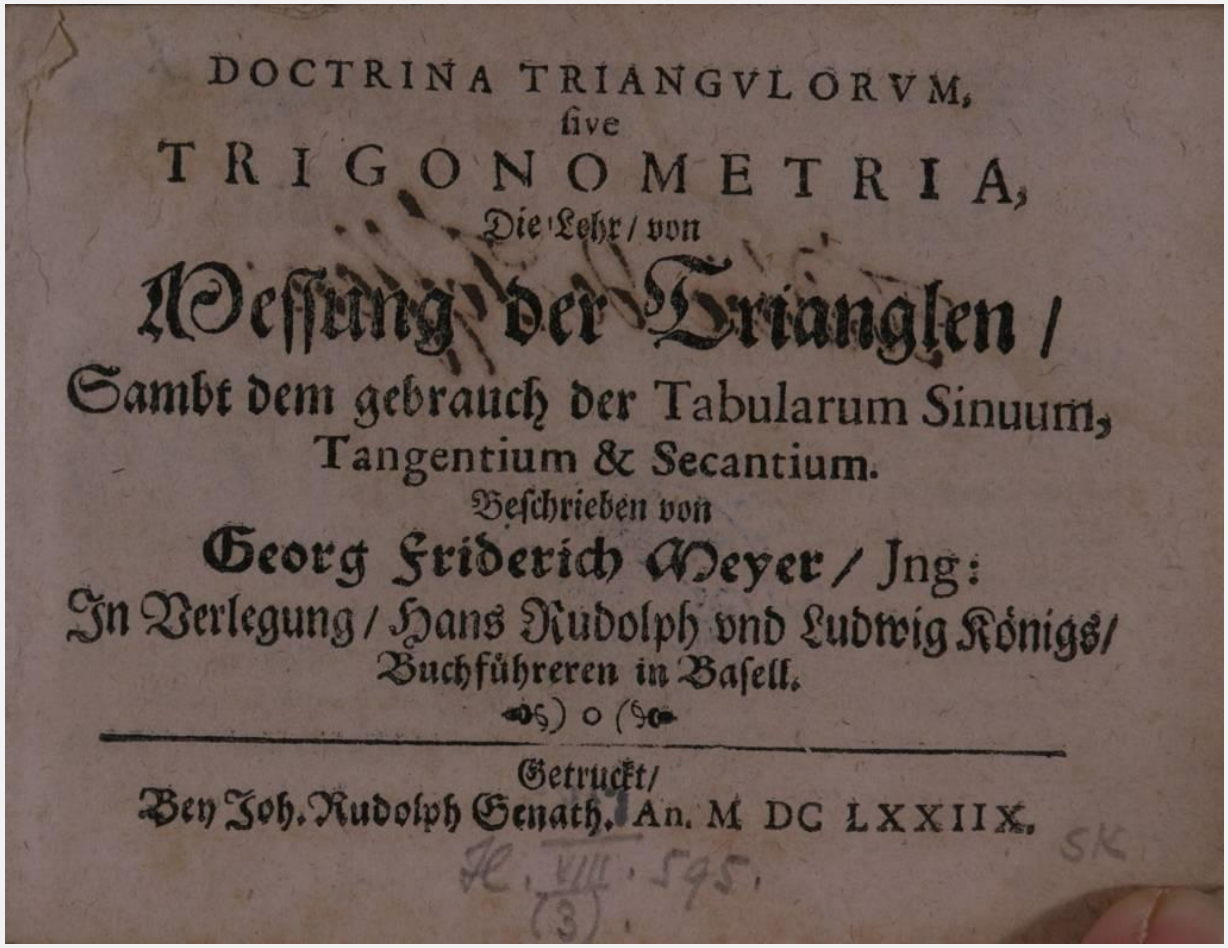
# Doctrina Triangulorum



DOCTRINA TRIANGVLORVM,
sive
TRIGONOMETRIA,
Die Lehr / von
Messung der Trianglen /
Sambt dem gebrauch der Tabularum Sinuum,
Tangentium & Secantium.
Beschrieben von
Georg Friderich Meyer / Jng:
In Verlegung / Hans Rudolph vnd Ludwig Königs/
Buchführeren in Basell.

Getruckt/
Bey Joh. Rudolph Genath. An. M DC LXXIIX.

Stadt- und Universitätsbibliothek Bern (StUB) H.VIII.595 (3)

Edition 1678



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# Doctrina Triangulorum


Stadt- und Universitätsbibliothek Bern (StUB) H.VIII.595 (3) Fig. 23

Measuring the width of the Rhine in Basel



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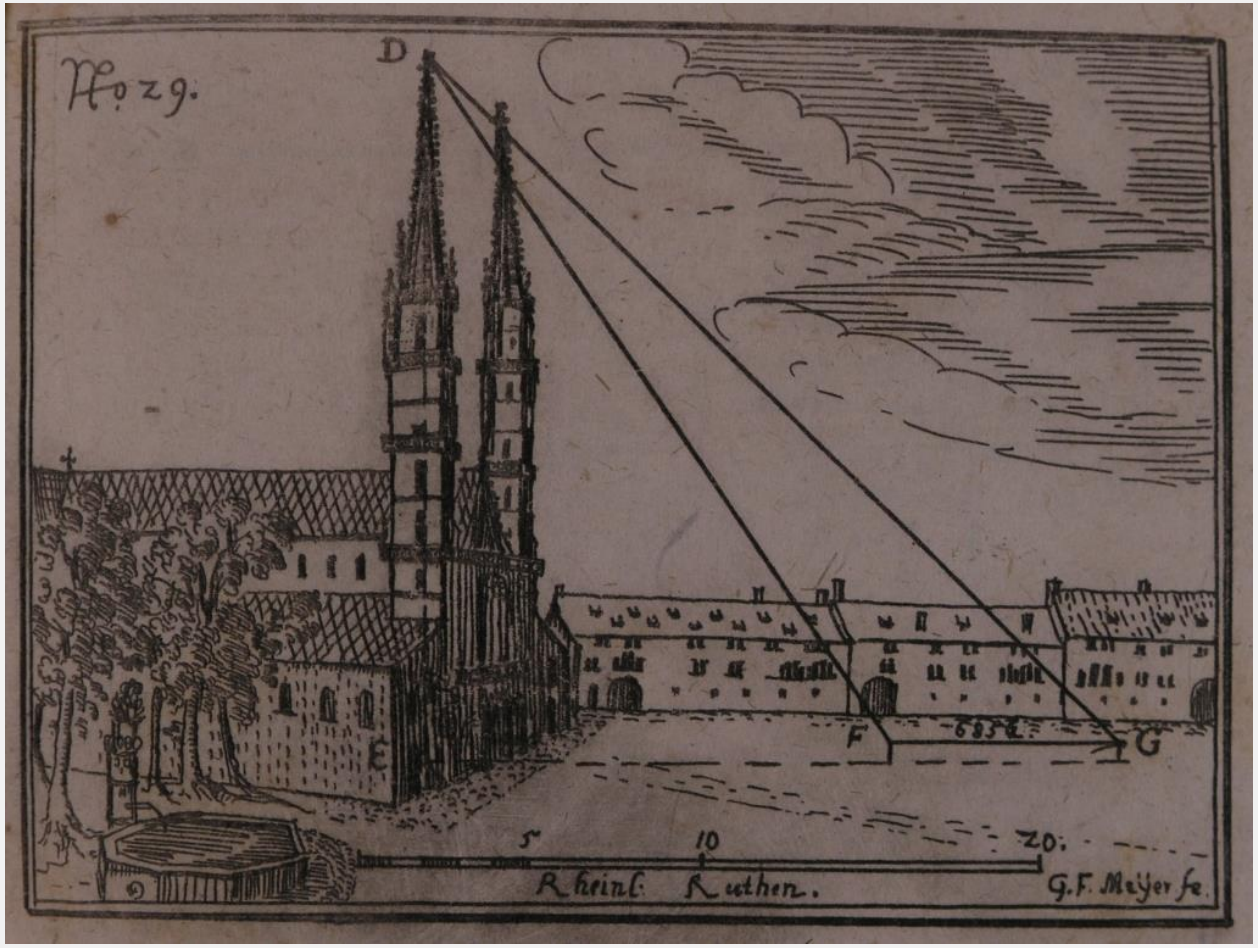
# Doctrina Triangulorum




Stadt- und Universitätsbibliothek Bern (StUB) H.VIII.595 (3) Fig. 29

Measuring the height of the Basel Cathedral



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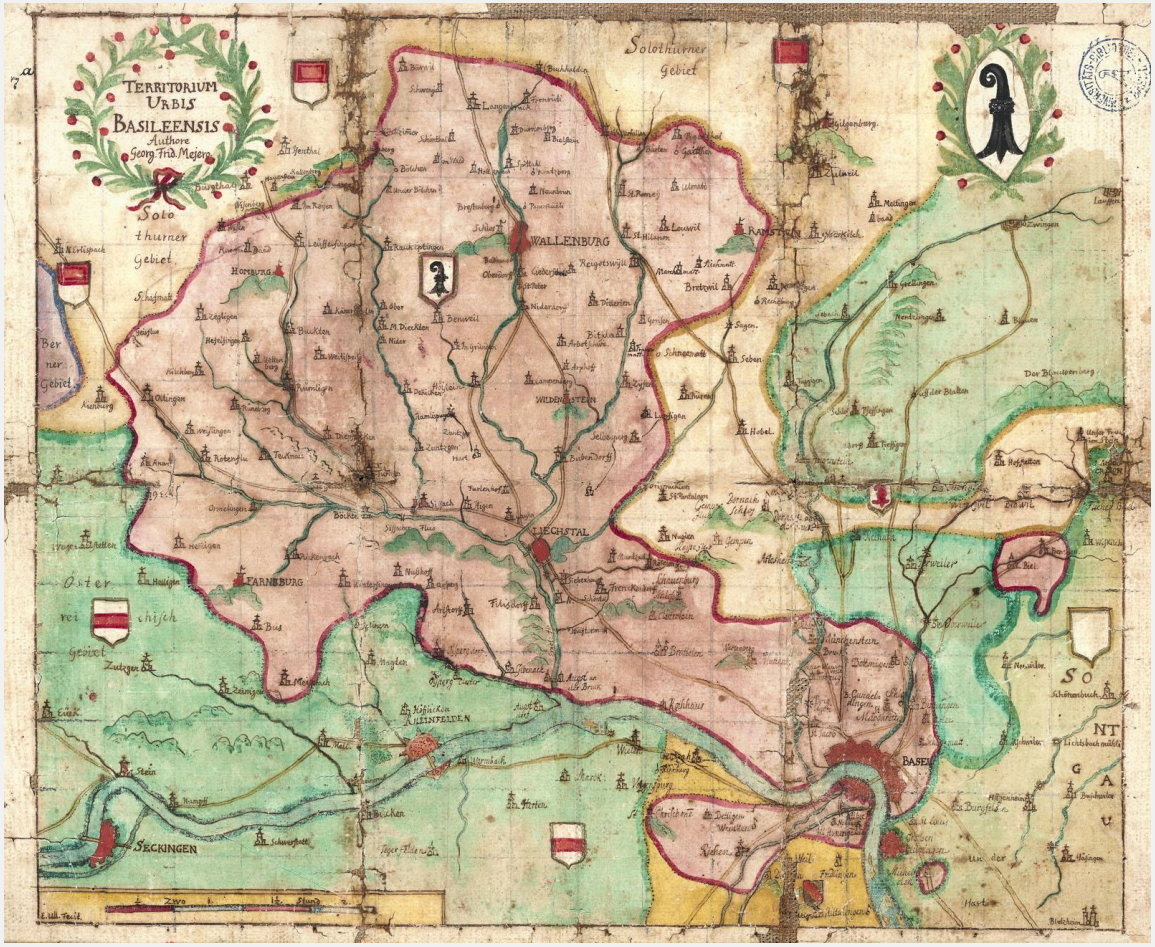
# Territorium Urbis Basileensis … 16??




Universitätsbibliothek Basel (UBBS) Kartensammlung Schw I C 7a

Georg Friedrich Meyer

Manuscript

34.6 x 29 cm

South oriented



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# Territorium Basileense … [1678]


Universitätsbibliothek Basel (UBBS) Kartensammlung Schw I C 8

Georg Friedrich Meyer

Manuscript, 78 x 61 cm

approx. 1 : 67 500

South oriented



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# Survey of Biel and Benken 1678


Staatsarchiv Basel-Landschaft KP 5003 0129a

Georg Friedrich Meyer

Surveying instruments

- Goniometer
- Compass
- Measuring chain



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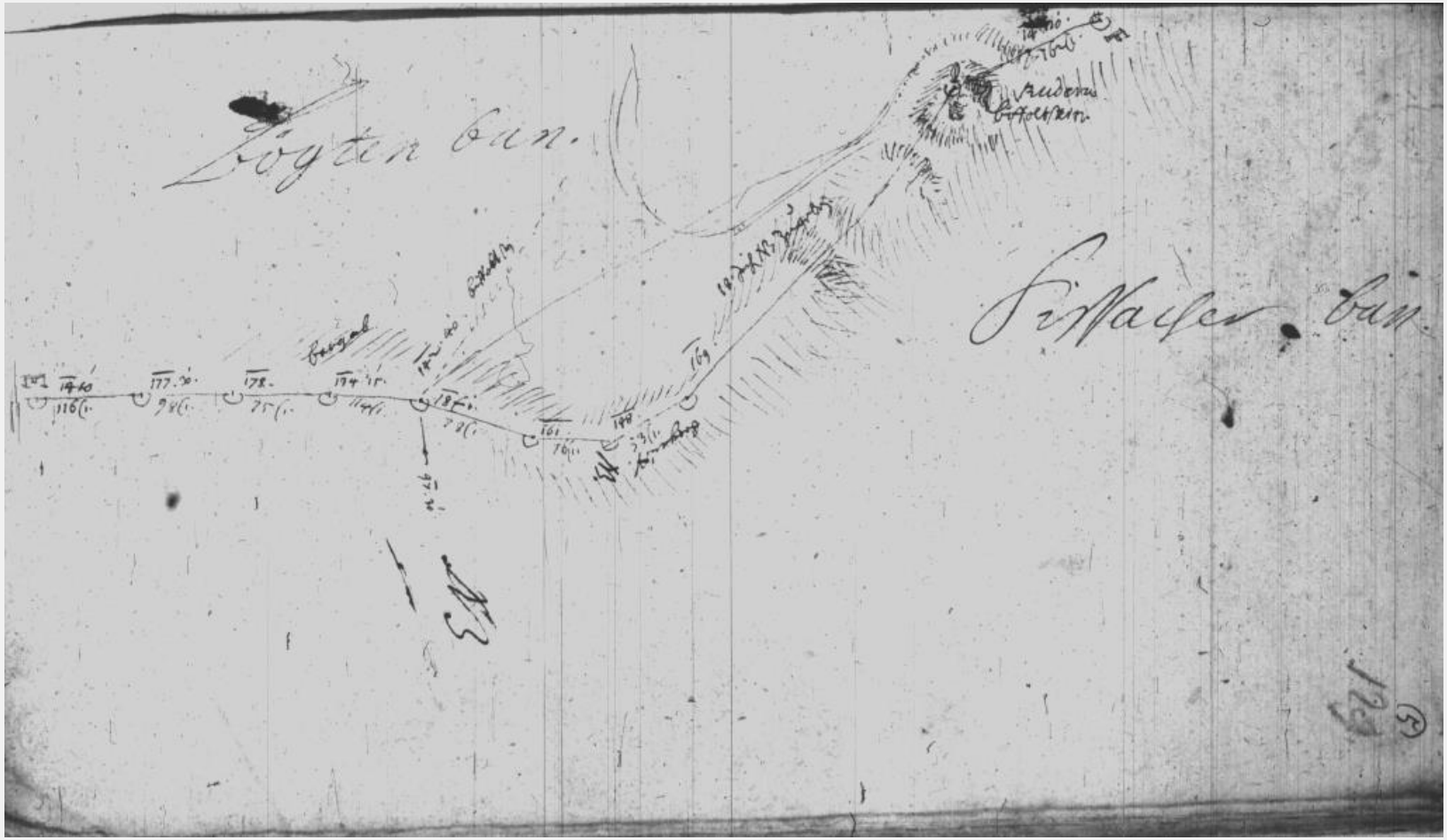
# Meyer sketches 1678 – 1683



Staatsarchiv Basel-Landschaft SL 5250 HS 0052/1 fol. 129



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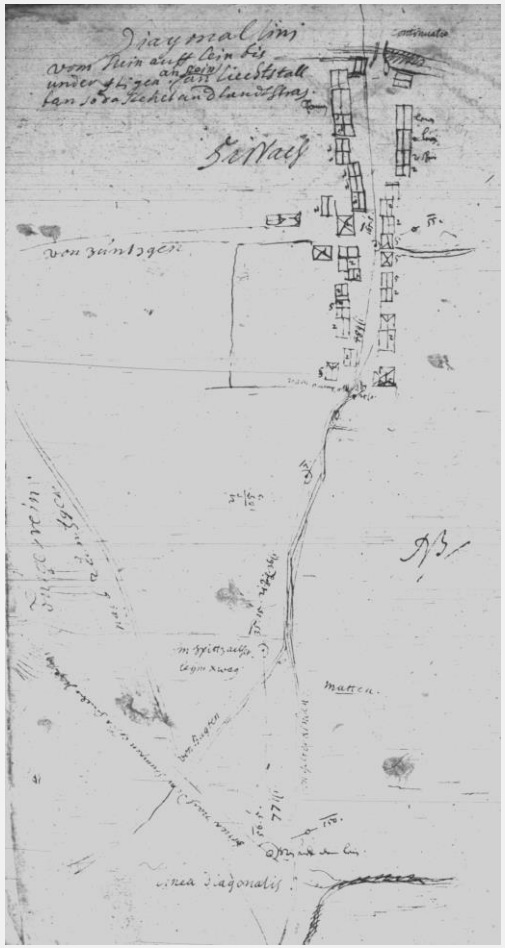
# Meyer sketches 1678 – 1683



Staatsarchiv Basel-Landschaft SL 5250 HS 0052/1 fol. 131

- complete survey of the territory of Basel
- polygons along the boundaries
- polygons along the valleys (diagonals)
- compilation between these sketches and the bailiwick maps was neccessary
- in the sense of a first fair drawing



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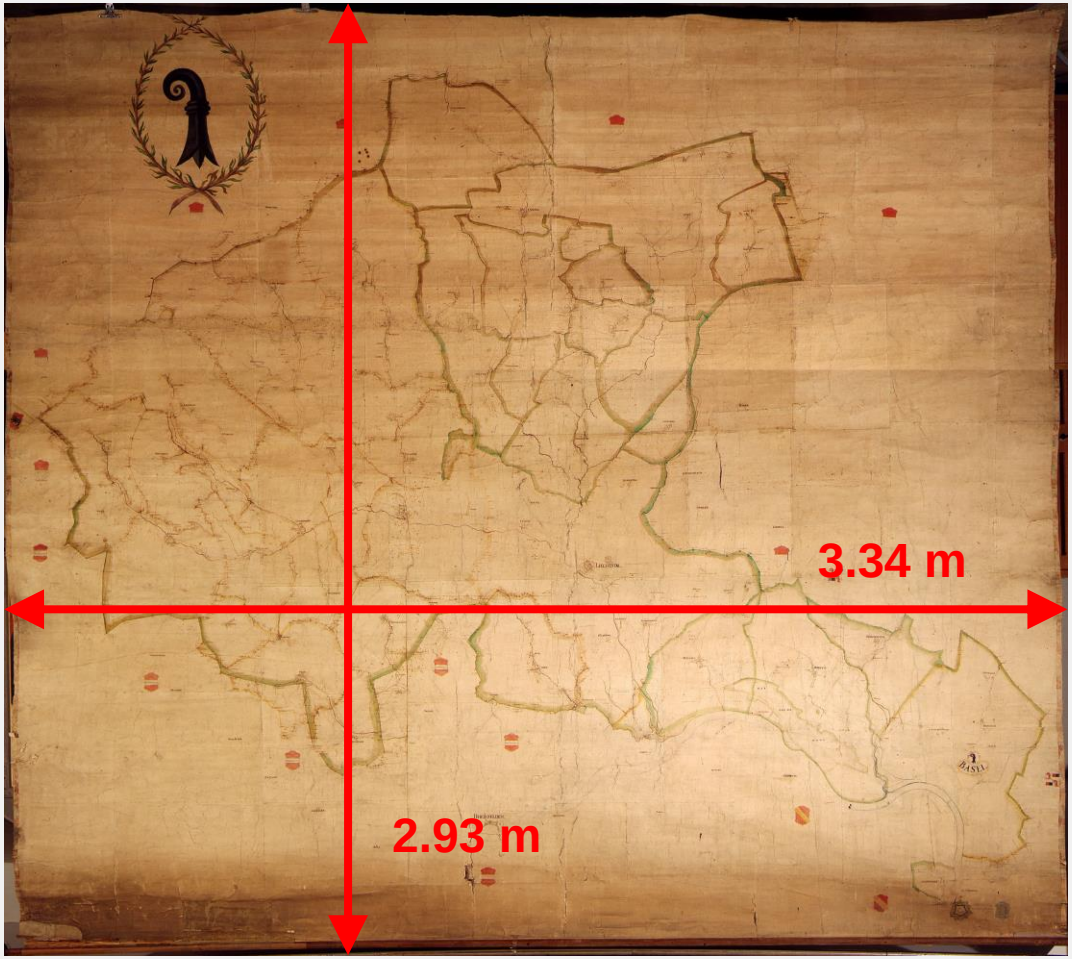
# The large Basel map from the 1680ies




- Outstanding size
- Emblem as title
- Representation of the Basel sphere of control
- No author
- No year
- South oriented
- State Archives of Basel-Stadt
  Plan T 267



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# Publications on the large Basel map

- Fritz Burckhardt: *Über Karten und Pläne des Baselgebietes* (1906)

  Description of the work of the first cartographers of the Basel region

- Paul Suter: *Beiträge zur Landschaftskunde des Ergolzgebietes* (1926)

  Studies in historical geography, based on this map

- Paul Suter: *Georg Friedrich Meyer, ein Basler Kartograph des 17. Jahrhunderts* (1933)

  Details on the surveying process

# Existing photos of the large Basel map

2 slides kept at the State Archives of Basel-Landschaft

Scanned by swisstopo with 2000 dpi
→ two files (~ 180 MB each)

Assembled to one image with 7961 x 8892 pixels (~ 207 MB)

Great disadvantages:
- dividing line visible
- geometry unknown

# Existing photos of the large Basel map




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# Actual state of the large Basel map

- Paul Suter, 1933: ‹The map is still situated in the State Archives of Basel on a fixed roll and is installed for handy rolling and unrolling›
- This easy access in earlier times had its price
- The map had not been unrolled for over 15 years
- Conservation measures were checked in 2001 but were found as too expensive
- Photos existing in the State Archives of Basel-Landschaft



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# Current state of the large Basel map



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# Current state of the large Basel map

Diameter ~ 17 cm, length ??? cm



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# Current state of the large Basel map



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# Current state of the large Basel map



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# Current state of the large Basel map



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# Elements of the large Basel map

Boundaries of the canton and the municipalities, detailed descriptions of the landmarks



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# Elements of the large Basel map


Ground views of the villages and towns



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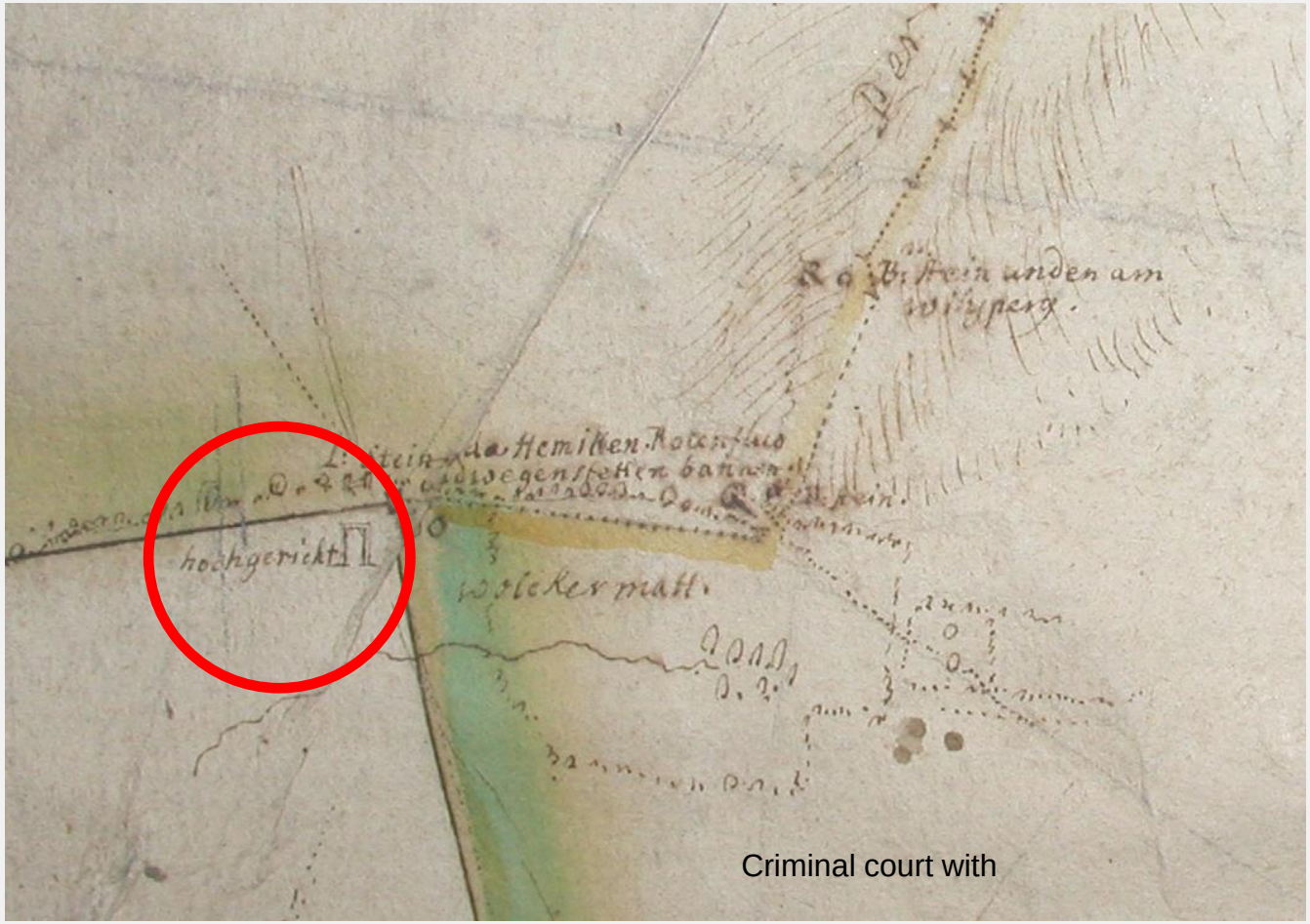
# Elements of the large Basel map


**I was born here!**

Hydrographic network
Road network

.. but also crevises and rifts

# Elements of the large Basel map




Criminal court with

Single objects such as e.g. a criminal court with gallows

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# Elements of the large Basel map


Only very rough information about terrain forms

No height information



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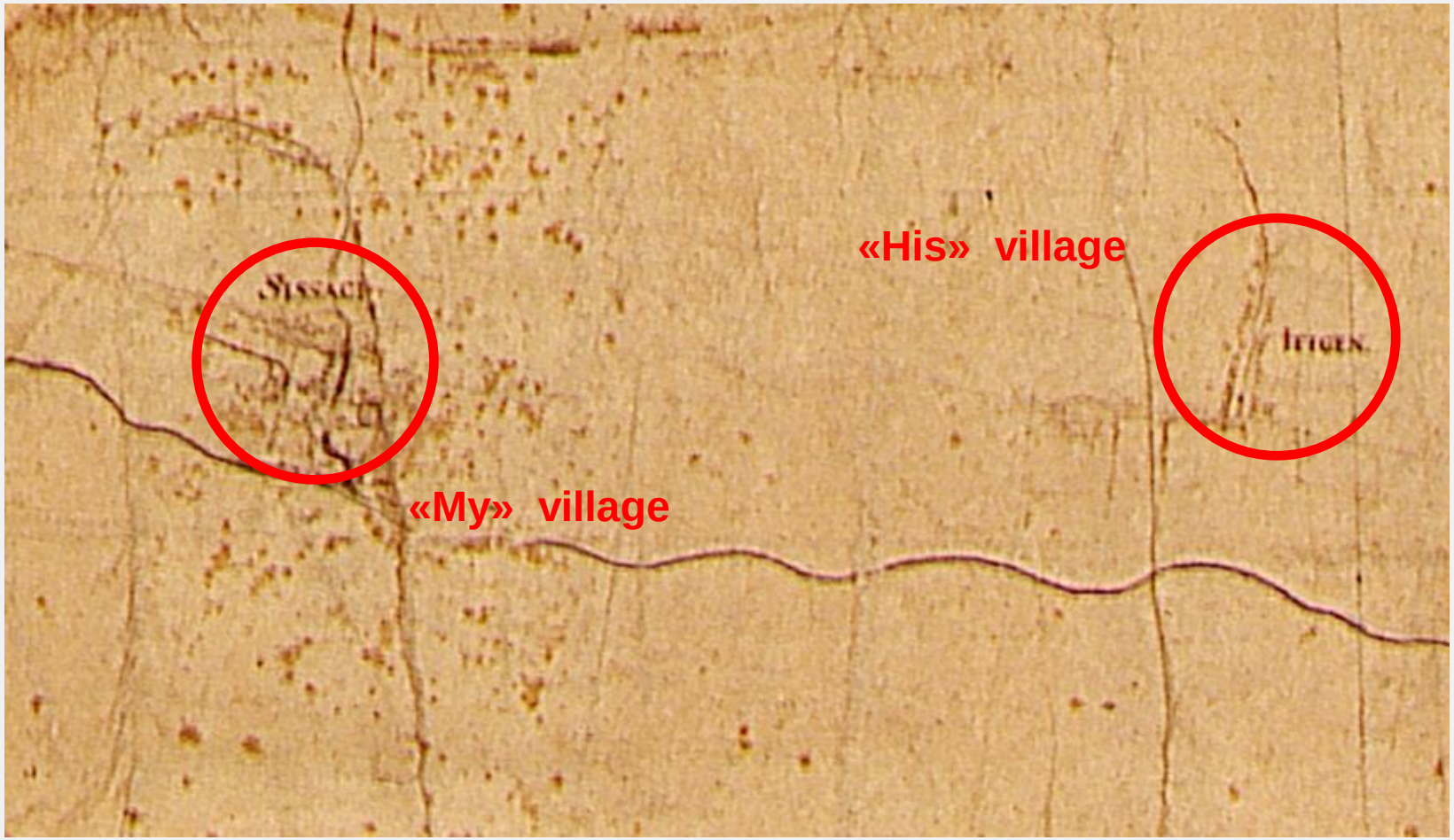
# Professor Nebiker and the large map



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# DigiMeyer – project idea

- Simulation of a «flight» over the map
- Using an analogous special camera for close range photogrammetric applications
- Scanning of the images with high resolution
- Ortho-rectification
- Digital assembly to a mosaic
- Final resolution in the mosaic: 0.1 mm
- Close affinity to processes in map actualization



DigiMeyer – the digitized large map of Basel

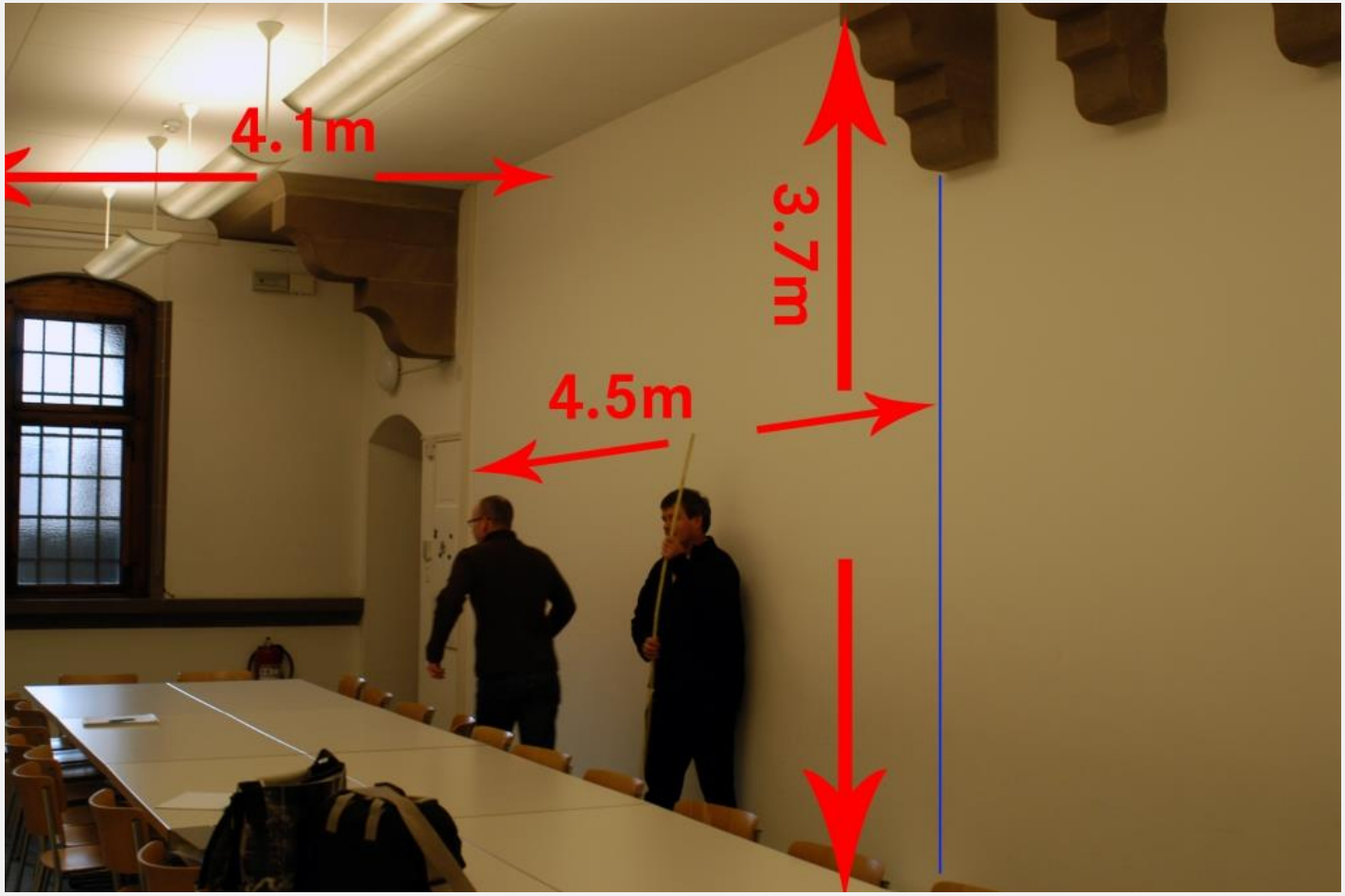
# DigiMeyer – project partners

- State Archives of Basel
  *customer, preparation of the map, finances*
- Photogrammetry group of the Basel University of Applied Sciences
  *technical concept, preparation, geodetic reference system, ortho-rectification, mosaiking*
- Photogrammetrie Perrinjaquet (subcontractor)
  *analogous camera CRC2, photographing, scanning*
- Martin Rickenbacher
  *project sketch, first user*



DigiMeyer – the digitized large map of Basel

# The digitizing process




Operation room in the State Archives of Basel-Stadt



DigiMeyer – the digitized large map of Basel

# The digitizing process - start

Beginning of the operation: Construction on the wall for holding the map



DigiMeyer – the digitized large map of Basel

# The digitizing process - preparation


Fixing the geodetic control points



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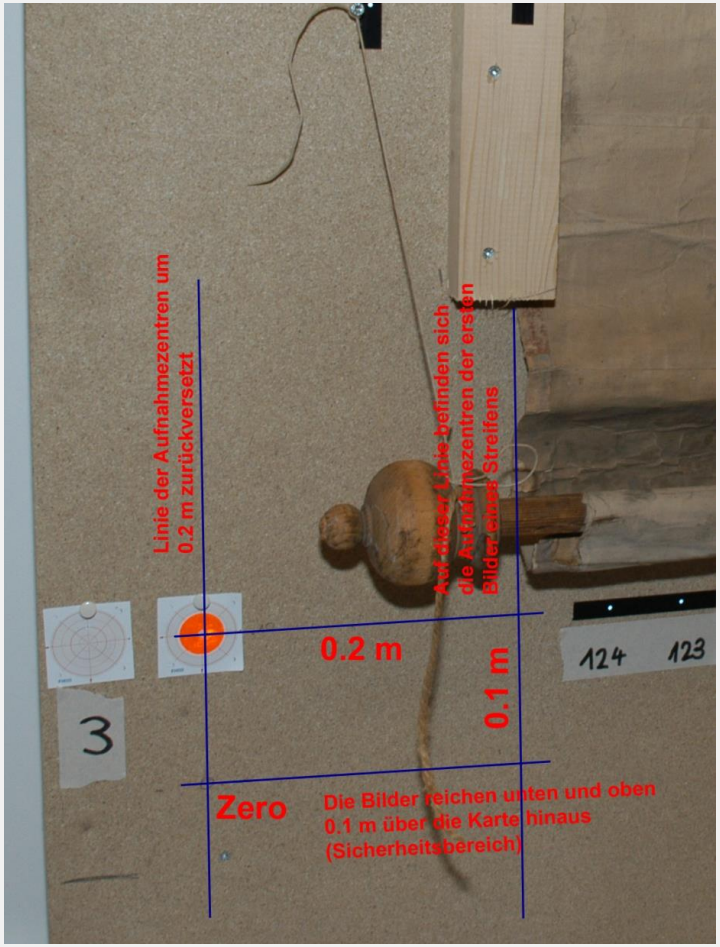
# The digitizing process - preparation




Point zero for the geodetic reference system

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# The digitizing process - preparation

Geodetic control unit for automatic registration

Measuring the geodetic control points from 2 stations

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# The digitizing process - preparation

Scaffold for the camera with track system to assure a constant distance between the camera and the map



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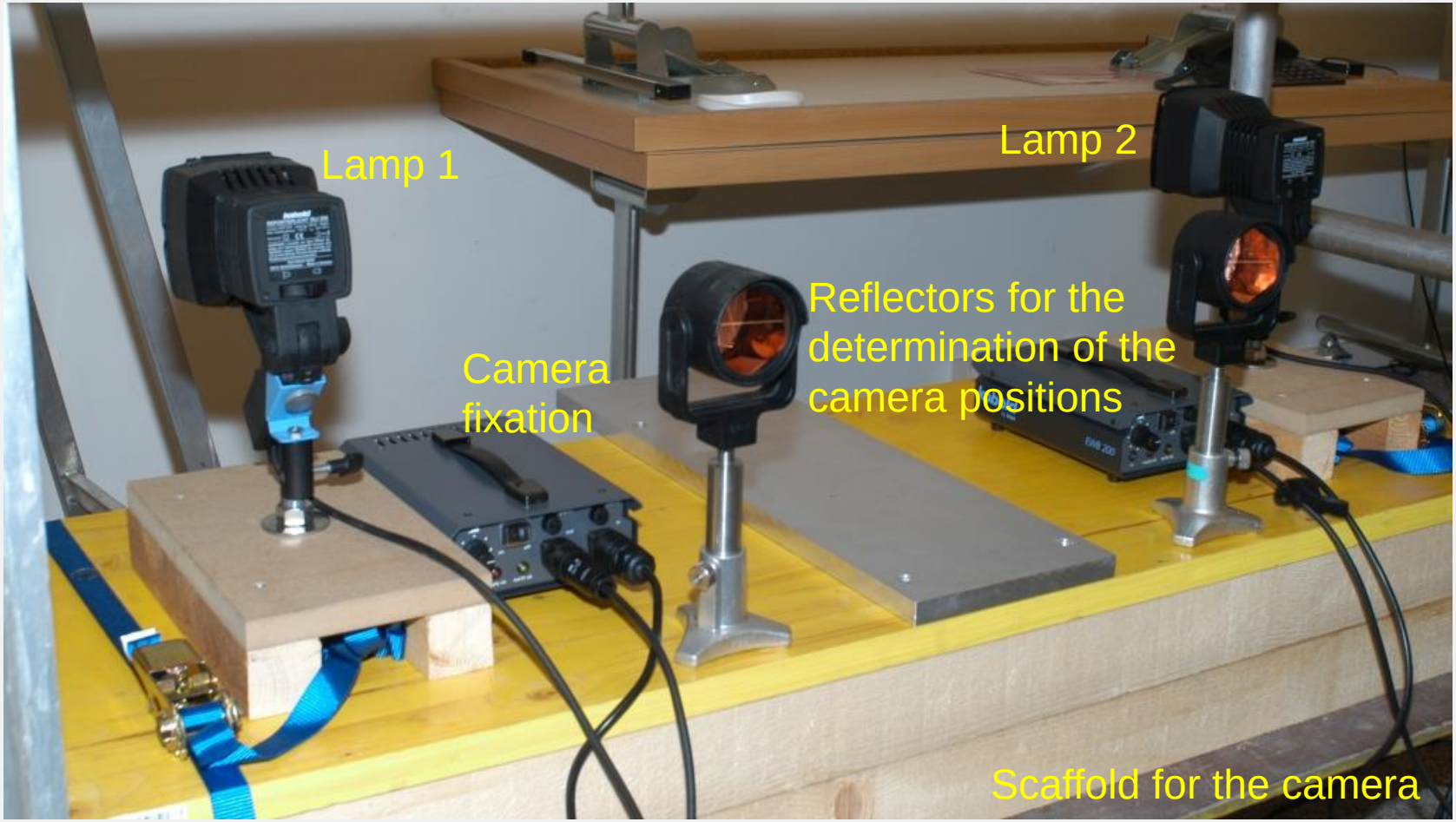
# The digitizing process - preparation



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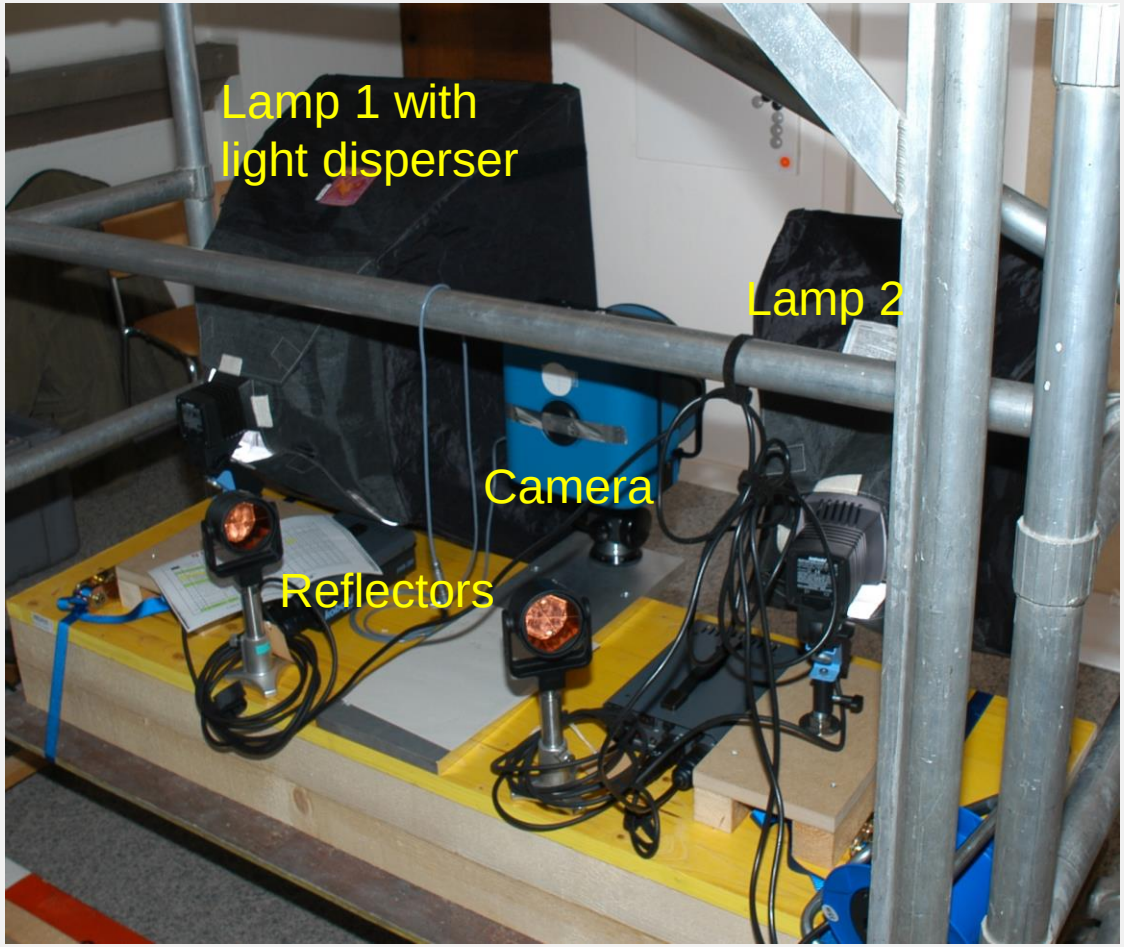
# The digitizing process - preparation




Scaffold with camera



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# The digitizing process - preparation




DigiMeyer – the digitized large map of Basel

# The digitizing process - preparation

Careful planning process prevented conflicts between the scaffold and the ceiling lights



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# The «flight» over the map

Documentation camera: a photo every 30 seconds



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# The «flight» over the map

You will now see the operations during the afternoon of the second day between 14:17 and 17:13 (176 minutes) compressed to 1:06 minutes

Please start the QuickTimePlayer

# The computation process

- Input: - coordinates of control points
  - scanned images (12 µm, 9160 x 9160 pix)
- Aerotriangulation
  Determination of the inner and outer orientation
- Digital Terrain Model (DTM) of the map surface
  Assures correct position of each pixel
- Ortho-mosaic
  Rectification of each photo and assembly
- Output: geometrically correct map data (0.1 mm)

# First application: Accuracy of the map

- Best basis for accuracy studies: Our large map
- «Meyer sketches» are not to scale
- Geometry of Bailiwick maps is not guaranteed
- One map is easier to research than five
- Very recently developed software is available
- Determination of identical points in old and new map
- Coordinate determination with ArcMap (GIS)
- Reference map: General Cadastral Map 1:5000



DigiMeyer – the digitized large map of Basel

# General Cadastral Map 1:5000 (GCM5000)

© KVA Basel-Landschaft

- Good relation to the scale of the large map
- Best reference
- Not generalized
- But differs from canton to canton
- Only black/white



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# Swiss National Map 1:25000 (NM25)




- Very legible map graphics
- But generalized
- Position differences may occur according to the cartographic drawing
- Used outside of Basel-Landschaft



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# GCM5000 versus NM25


In red and below: GCM25

Above: NM25

Argument for the use of GCM5000 as reference



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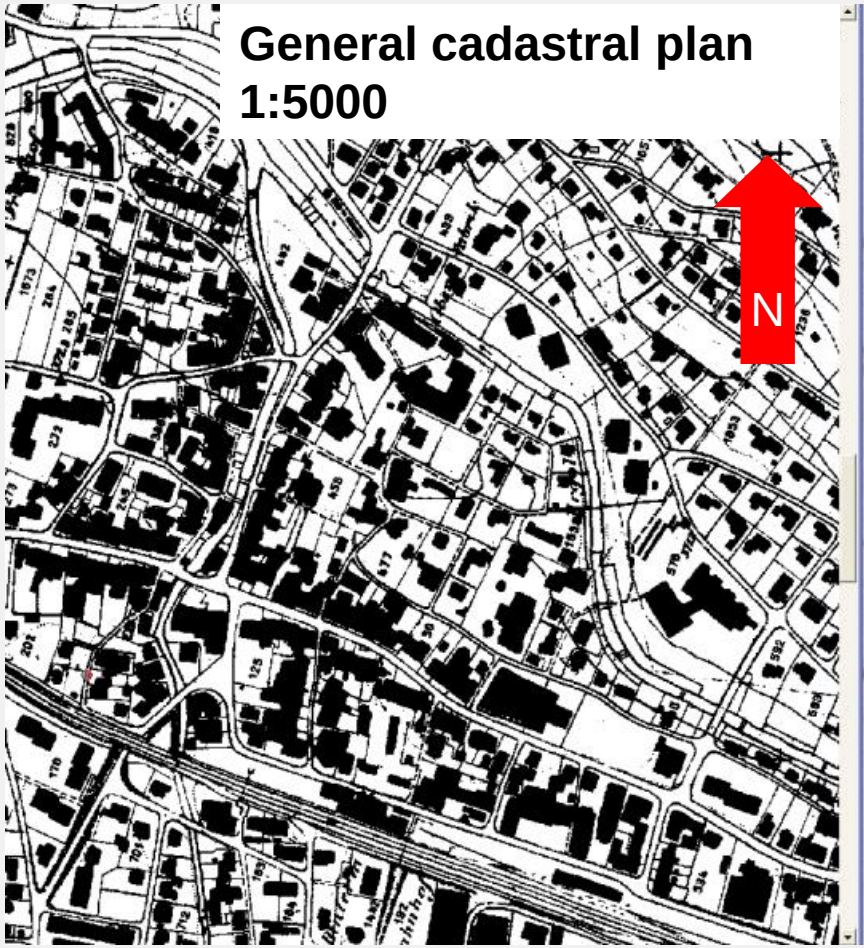
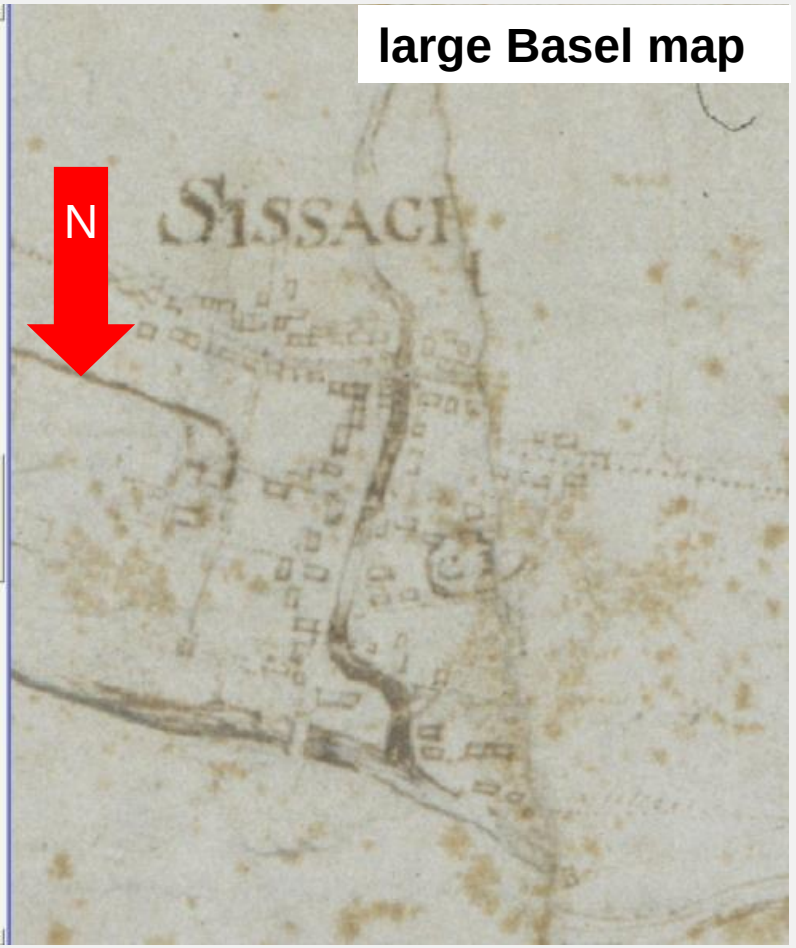
# First step: Determination of identical points



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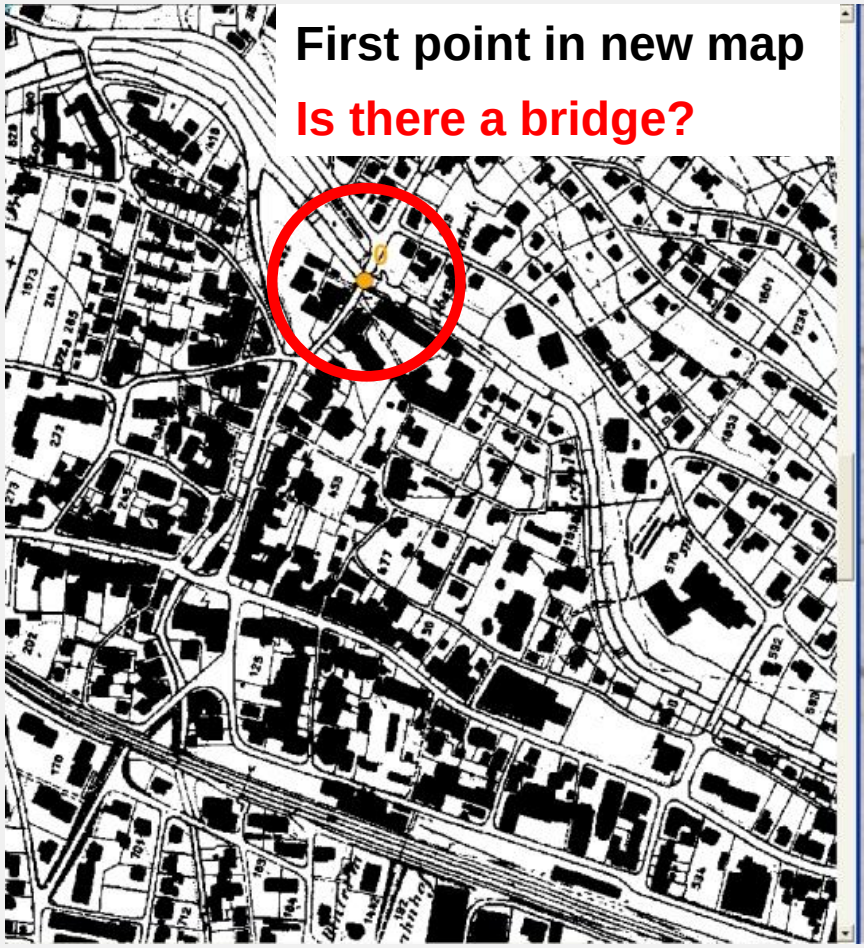
# First step: Determination of identical points

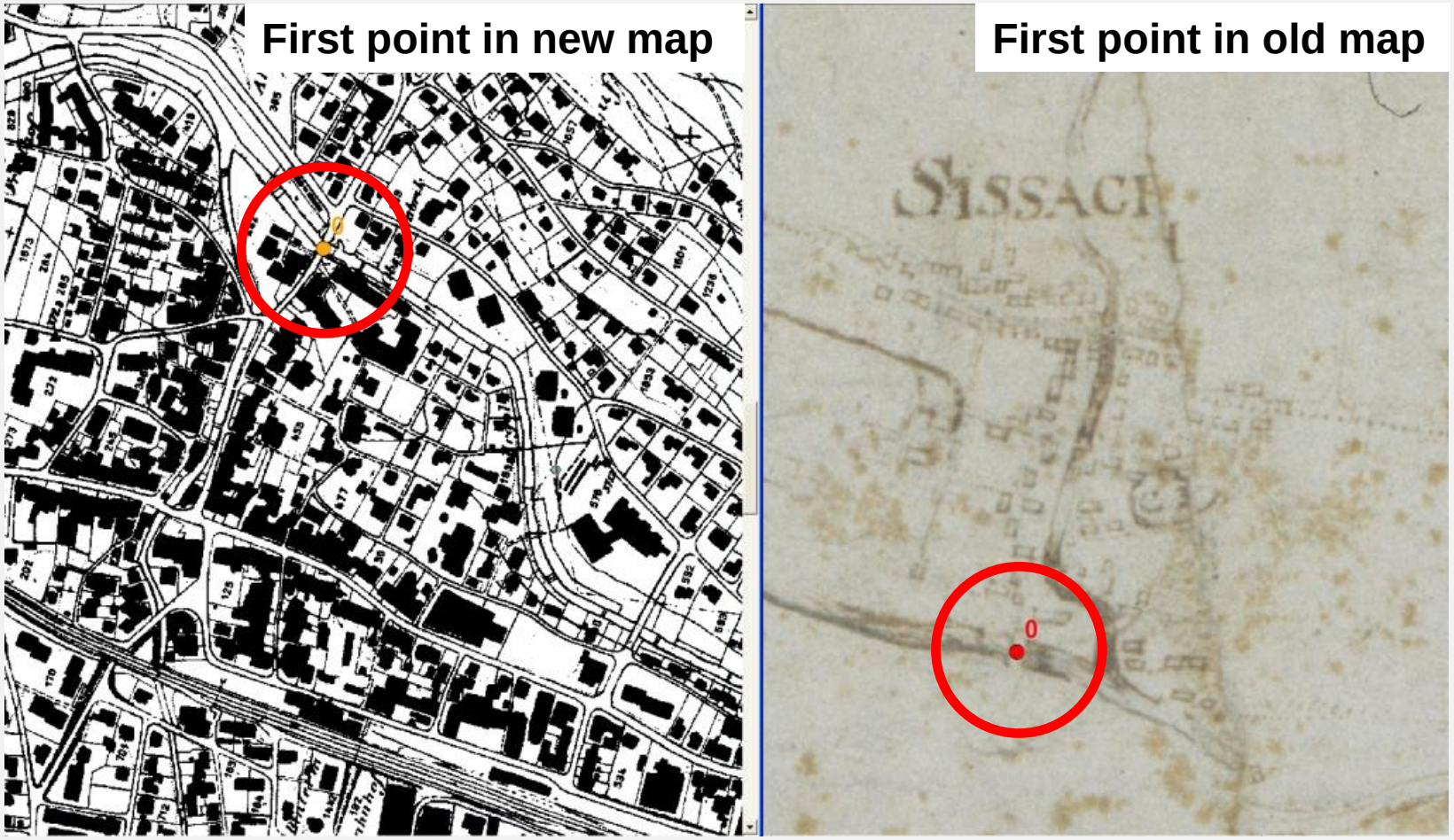






DigiMeyer – the digitized large map of Basel

# First step: Determination of identical points






DigiMeyer – the digitized large map of Basel

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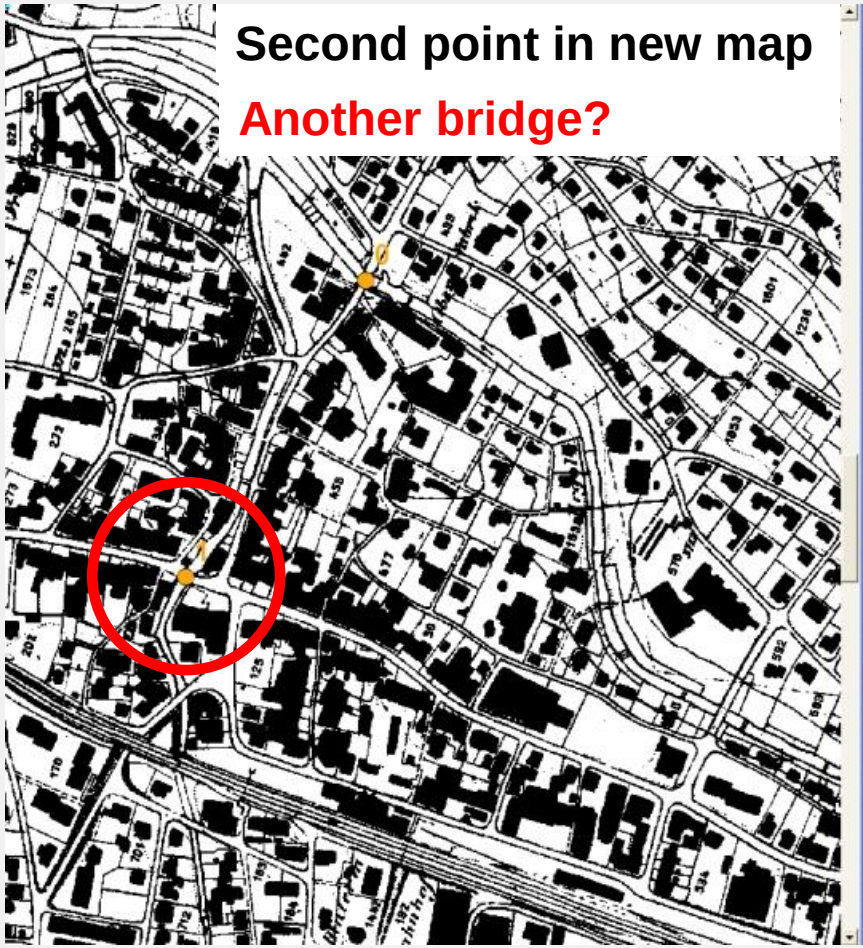


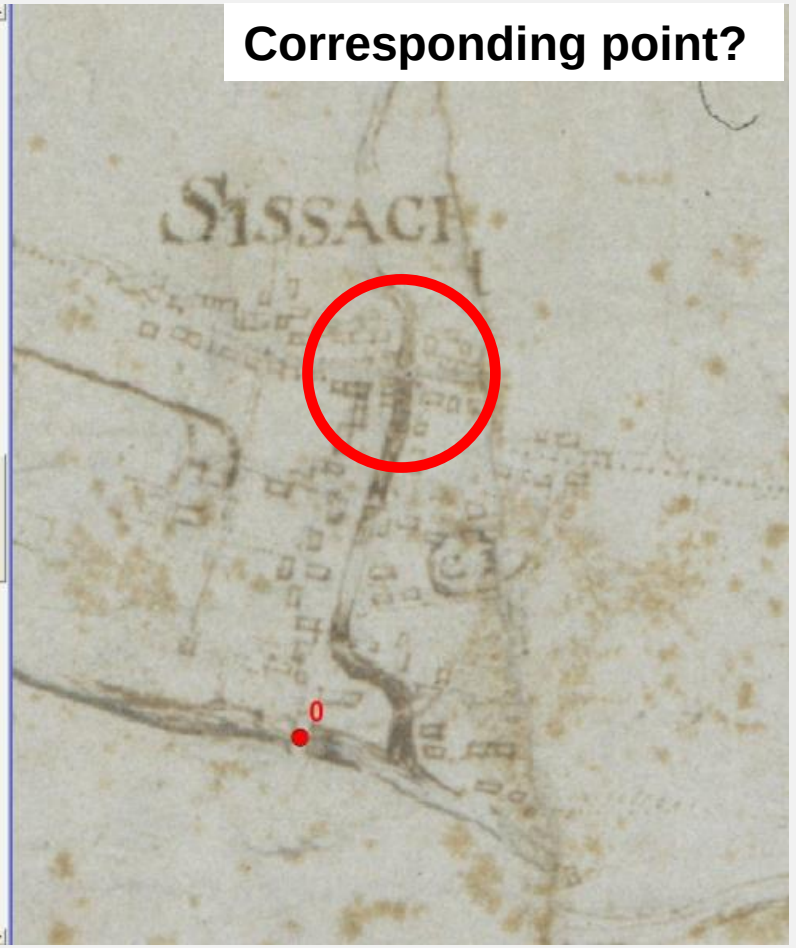




DigiMeyer – the digitized large map of Basel

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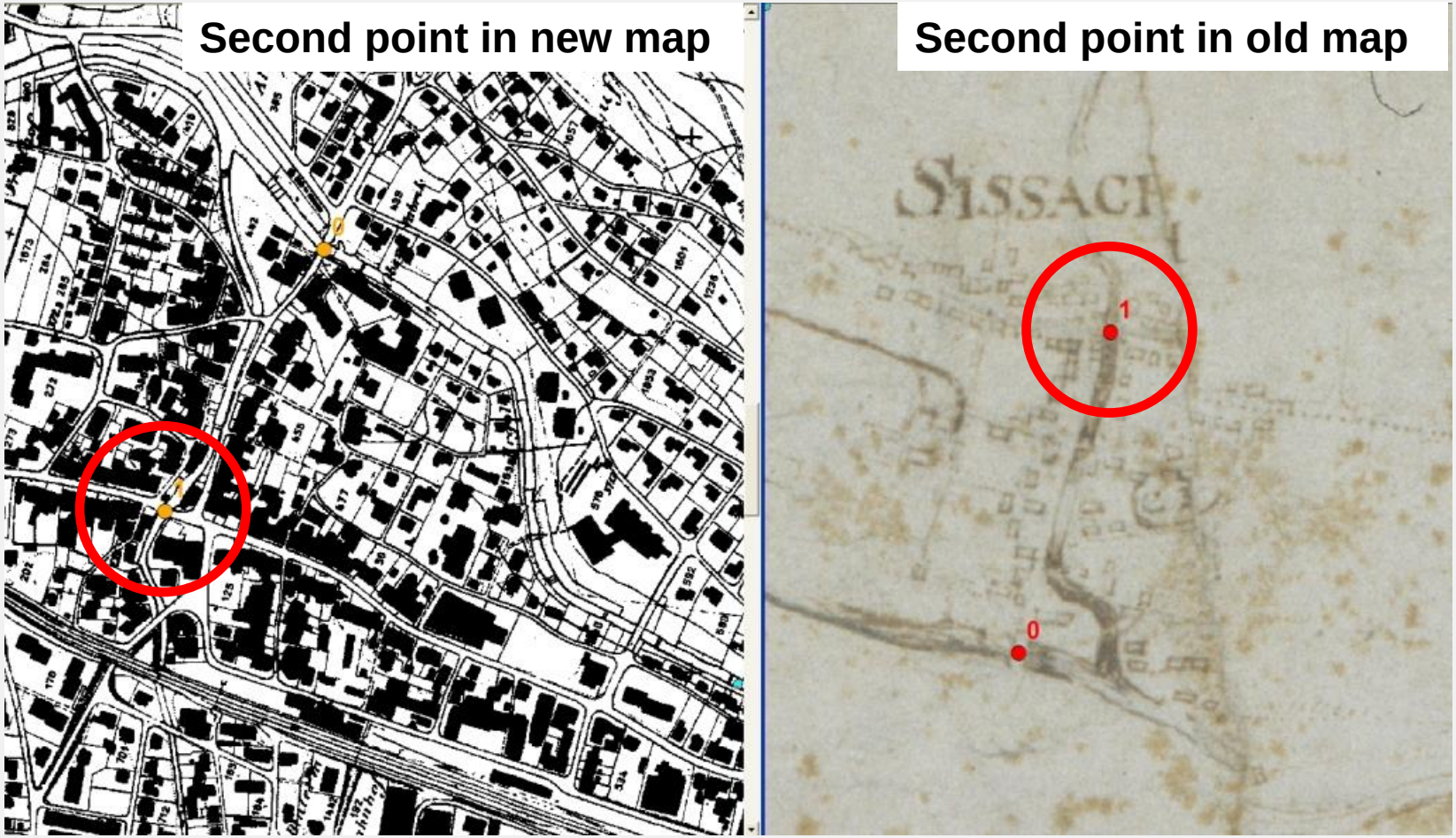





DigiMeyer – the digitized large map of Basel

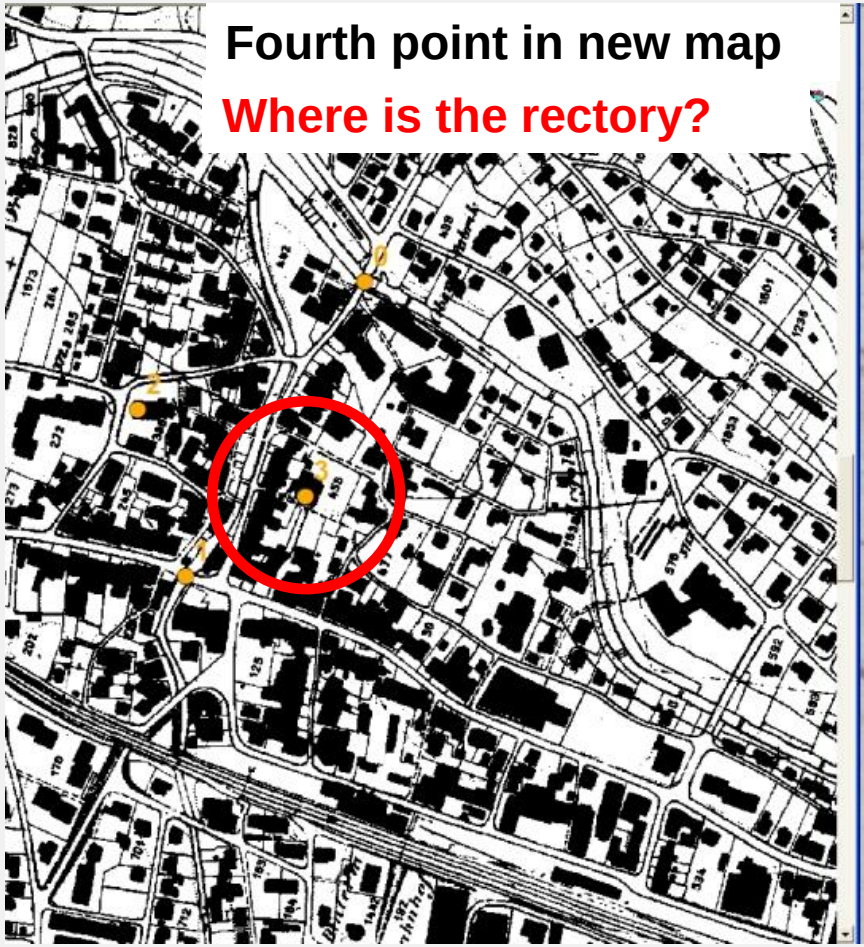
# First step: Determination of identical points





DigiMeyer – the digitized large map of Basel

# First step: Determination of identical points







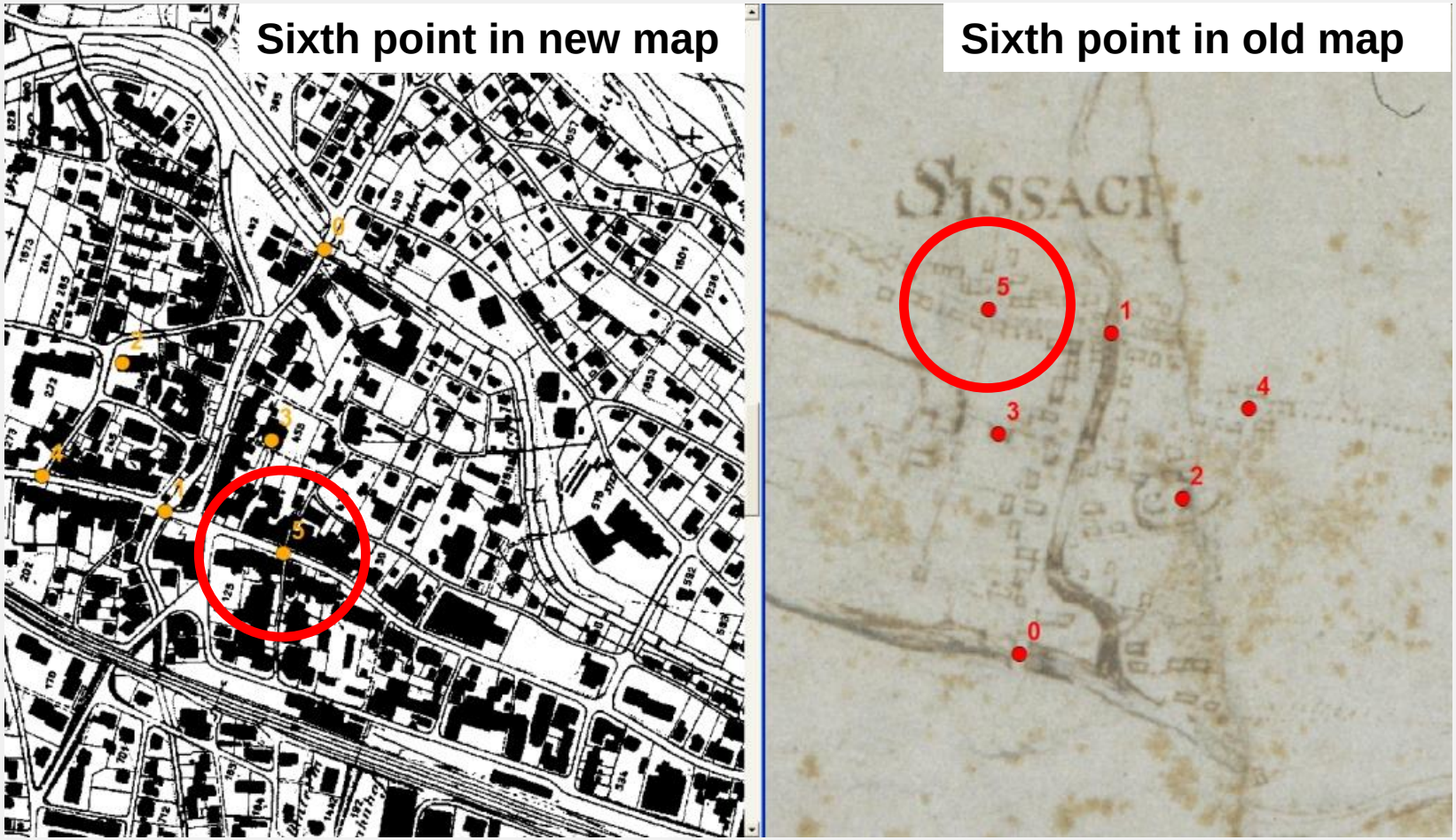
DigiMeyer – the digitized large map of Basel

# First step: Determination of identical points




DigiMeyer – the digitized large map of Basel

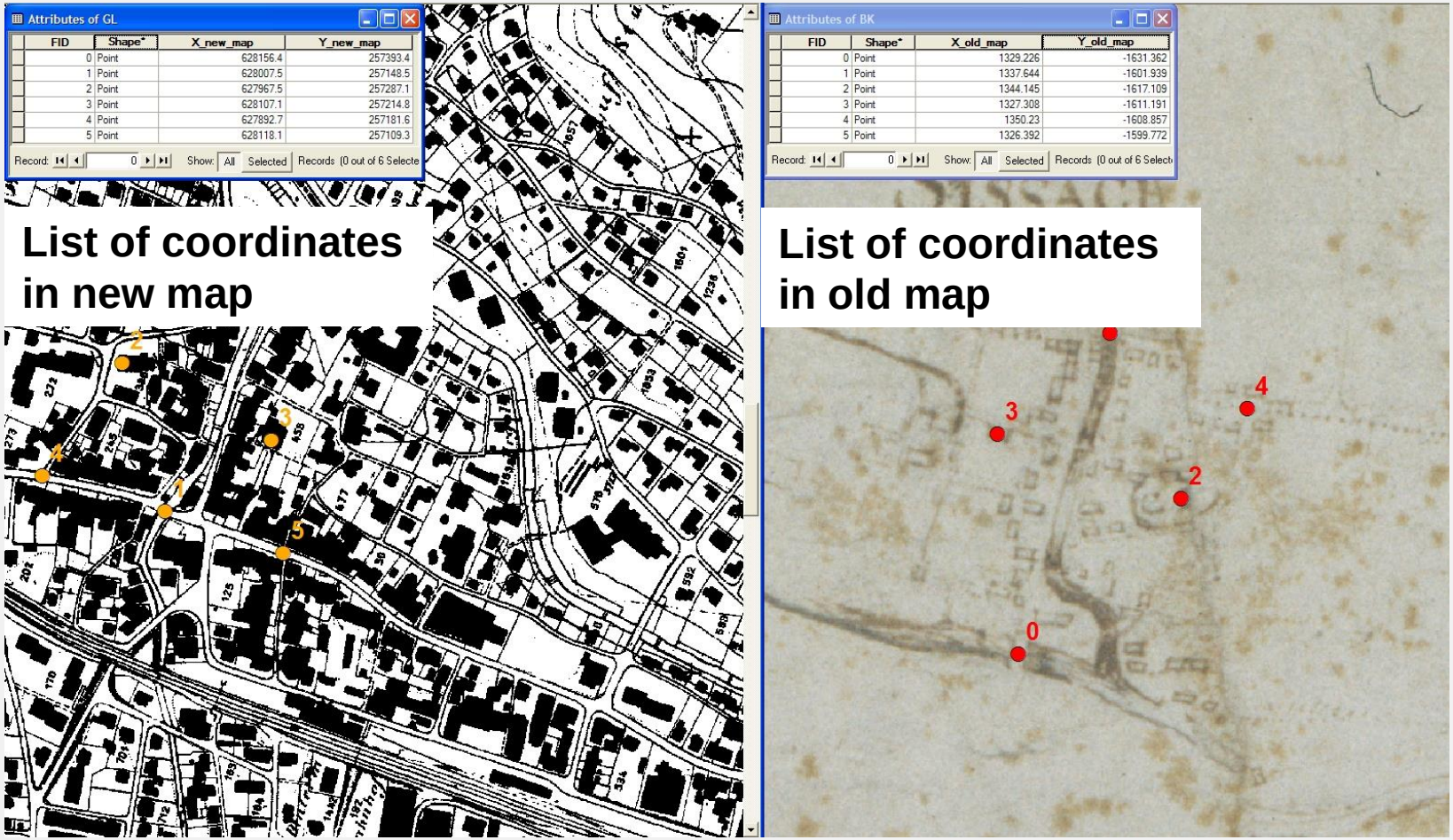
# First step: Determination of identical points






DigiMeyer – the digitized large map of Basel

# First step: Determination of identical points






DigiMeyer – the digitized large map of Basel

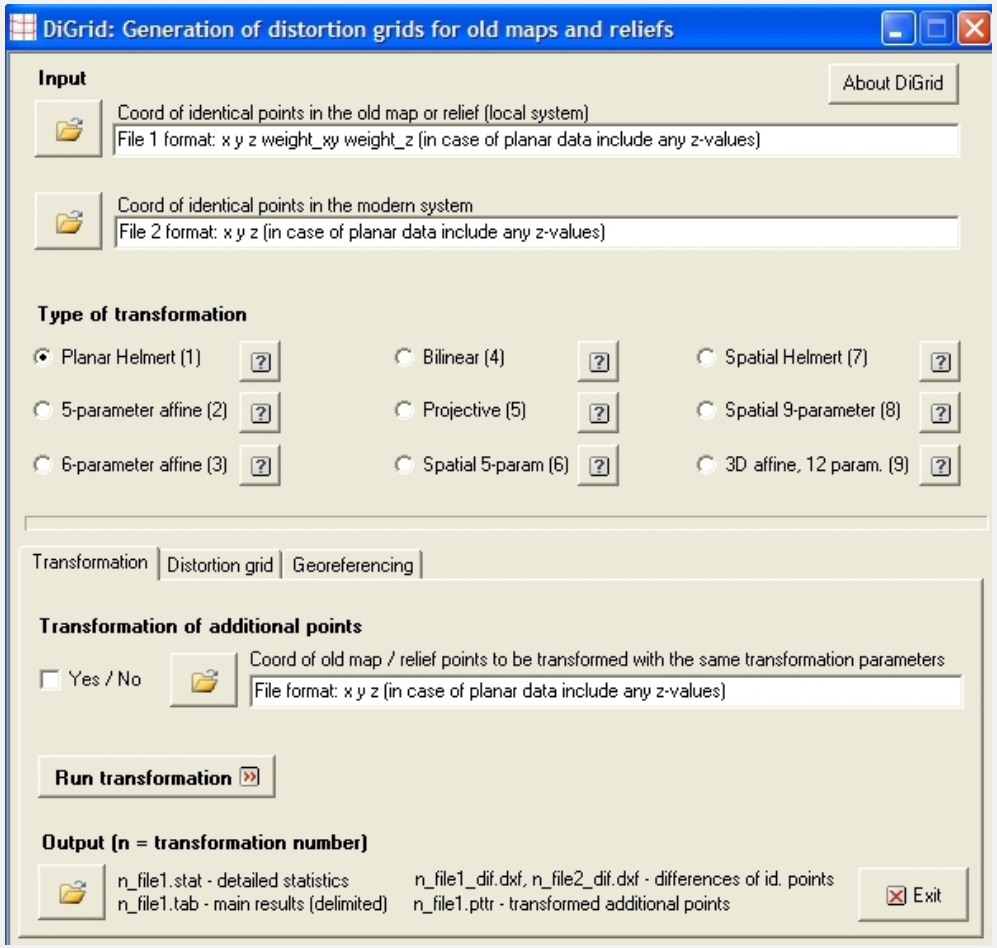
# Second step: Transformations and checks

- Input
  coordinate sets of the identical points for the old and the new map
- 4-parameter transformation (Helmert)
- 5-parameter affine transformation
- 6-parameter affine transformation
- Best fitting transformation has the lowest a posteriori sigma (sigma0, s0)
- Check for every point pair with differences >3*s0
- Two programs available: DiGrid and MapAnalyst

# DiGrid – Software for Distortion Grids

- Author: Dr. Jana Niederöst, ETH Zurich
- Coordinate determination and visualization with a GIS system as e.g. ArcMap (ESRI)
- All 3 transformation types implemented
- Accuracy and metric parameters of the old map
- Calculation of distortion grids in old and new map
- For details and contact: www.photogrammetry.ethz.ch/research/pfyffer/
- Tool for the advanced user

# DiGrid – Software for Distortion Grids

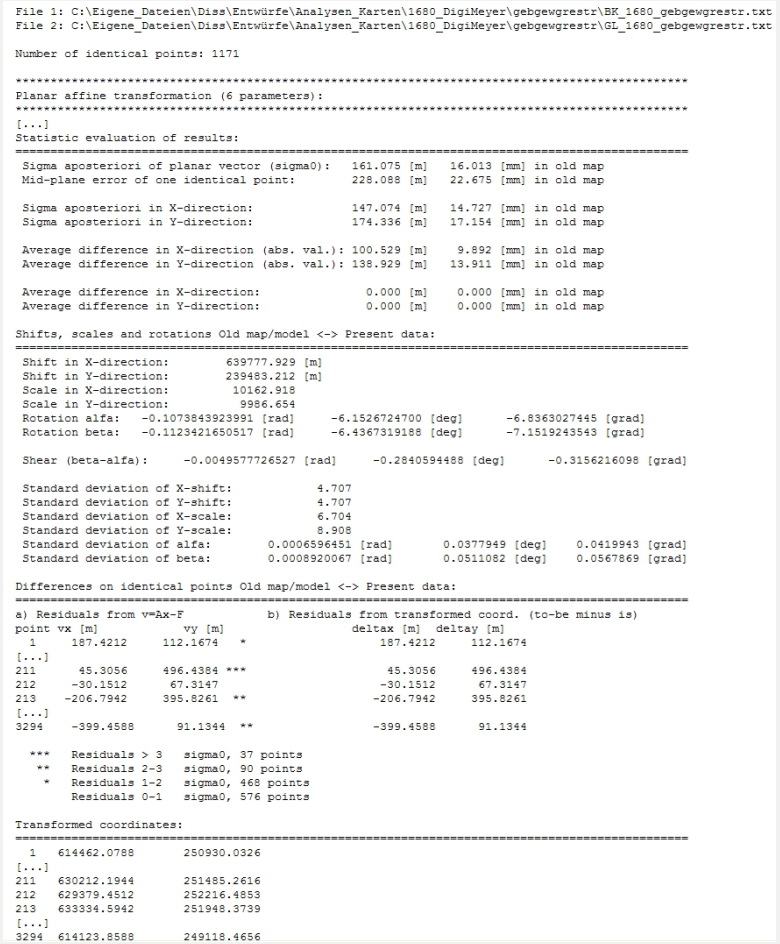



Self explanatory user interface



DigiMeyer – the digitized large map of Basel

# DiGrid – Output protocol



```
File 1: C:\Eigene_Dateien\Diss\Entwürfe\Analysen_Karten\1680_DigiMeyer\gebgewgrestr\BK_1680_gebgewgrestr.txt
File 2: C:\Eigene_Dateien\Diss\Entwürfe\Analysen_Karten\1680_DigiMeyer\gebgewgrestr\GL_1680_gebgewgrestr.txt

Number of identical points: 1171

*****************************************************************************************
Planar affine transformation (6 parameters):
*****************************************************************************************
[...]
Statistic evaluation of results:
=========================================================================================
 Sigma aposteriori of planar vector (sigma0):   161.075 [m]   16.013 [mm] in old map
 Mid-plane error of one identical point:        228.088 [m]   22.675 [mm] in old map

 Sigma aposteriori in X-direction:              147.074 [m]   14.727 [mm] in old map
 Sigma aposteriori in Y-direction:              174.336 [m]   17.154 [mm] in old map

 Average difference in X-direction (abs. val.): 100.529 [m]    9.892 [mm] in old map
 Average difference in Y-direction (abs. val.): 138.929 [m]   13.911 [mm] in old map

 Average difference in X-direction:               0.000 [m]    0.000 [mm] in old map
 Average difference in Y-direction:               0.000 [m]    0.000 [mm] in old map

Shifts, scales and rotations Old map/model <-> Present data:
=========================================================================================
 Shift in X-direction:        639777.929 [m]
 Shift in Y-direction:        239483.212 [m]
 Scale in X-direction:         10162.918
 Scale in Y-direction:          9986.654
 Rotation alfa:   -0.1073843923991 [rad]     -6.1526724700 [deg]      -6.8363027445 [grad]
 Rotation beta:   -0.1123421650517 [rad]     -6.4367319188 [deg]      -7.1519243543 [grad]

 Shear (beta-alfa):     -0.0049577726527 [rad]     -0.2840594488 [deg]      -0.3156216098 [grad]

 Standard deviation of X-shift:            4.707
 Standard deviation of Y-shift:            4.707
 Standard deviation of X-scale:            6.704
 Standard deviation of Y-scale:            8.908
 Standard deviation of alfa:        0.0006596451 [rad]       0.0377949 [deg]    0.0419943 [grad]
 Standard deviation of beta:        0.0008920067 [rad]       0.0511082 [deg]    0.0567869 [grad]

Differences on identical points Old map/model <-> Present data:
=========================================================================================
a) Residuals from v=Ax-F            b) Residuals from transformed coord. (to-be minus is)
point vx [m]          vy [m]                deltax [m]  deltay [m]
  1     187.4212     112.1674   *              187.4212     112.1674
[...]
211      45.3056     496.4384 ***               45.3056     496.4384
212     -30.1512      67.3147                  -30.1512      67.3147
213    -206.7942     395.8261  **             -206.7942     395.8261
[...]
3294    -399.4588      91.1344  **             -399.4588      91.1344

  ***   Residuals > 3   sigma0, 37 points
   **   Residuals 2-3   sigma0, 90 points
    *   Residuals 1-2   sigma0, 468 points
        Residuals 0-1   sigma0, 576 points

Transformed coordinates:
=========================================================================================
  1   614462.0788       250930.0326
[...]
211   630212.1944       251485.2616
212   629379.4512       252216.4853
213   633334.5942       251948.3739
[...]
3294  614123.8588       249118.4656
```

Input files

Transformation formula (omitted)

Statistic evaluation of results

Shifts, scales and rotations

Differences on identical points

Transformed coordinates



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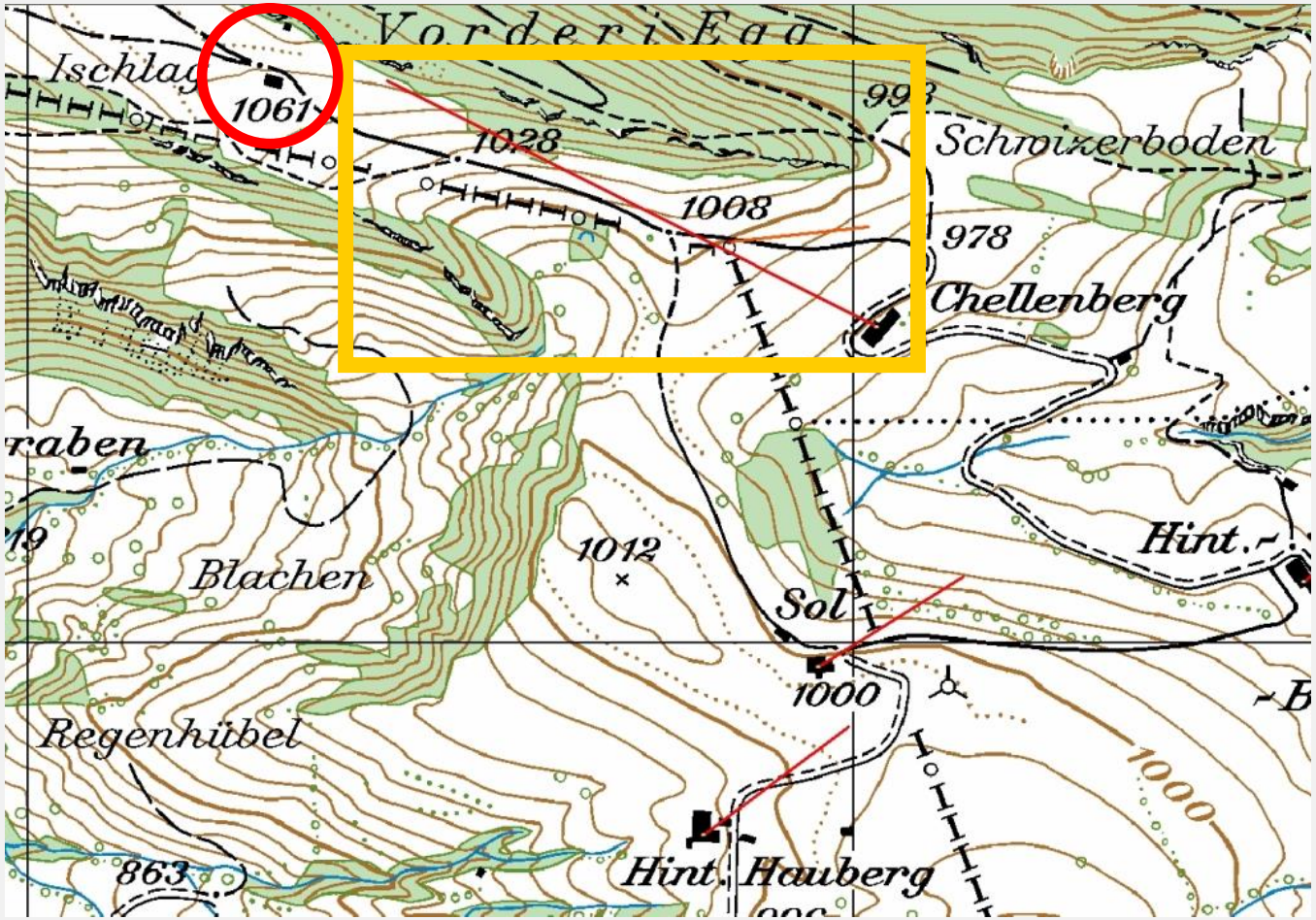
# MapAnalyst – Freeware

- Very recently developed (V1.0, June 30, 2005)
- Authors: Adrian Weber (student ETHZ), assisted by dipl. Ing. Bernhard Jenny (Institute of Cartography ETHZ)
- Integral system (integrated coordinate determination)
- 4 transformation types implemented (in addition: Robust Helmert Estimator)
- Main target audience: people interested in old maps
- For details and contact: www.ika.ethz.ch/mapanalyst/
- Report (in German only): www.ika.ethz.ch/teaching/VTB-Weber.pdf

# Second step: Transformations and checks

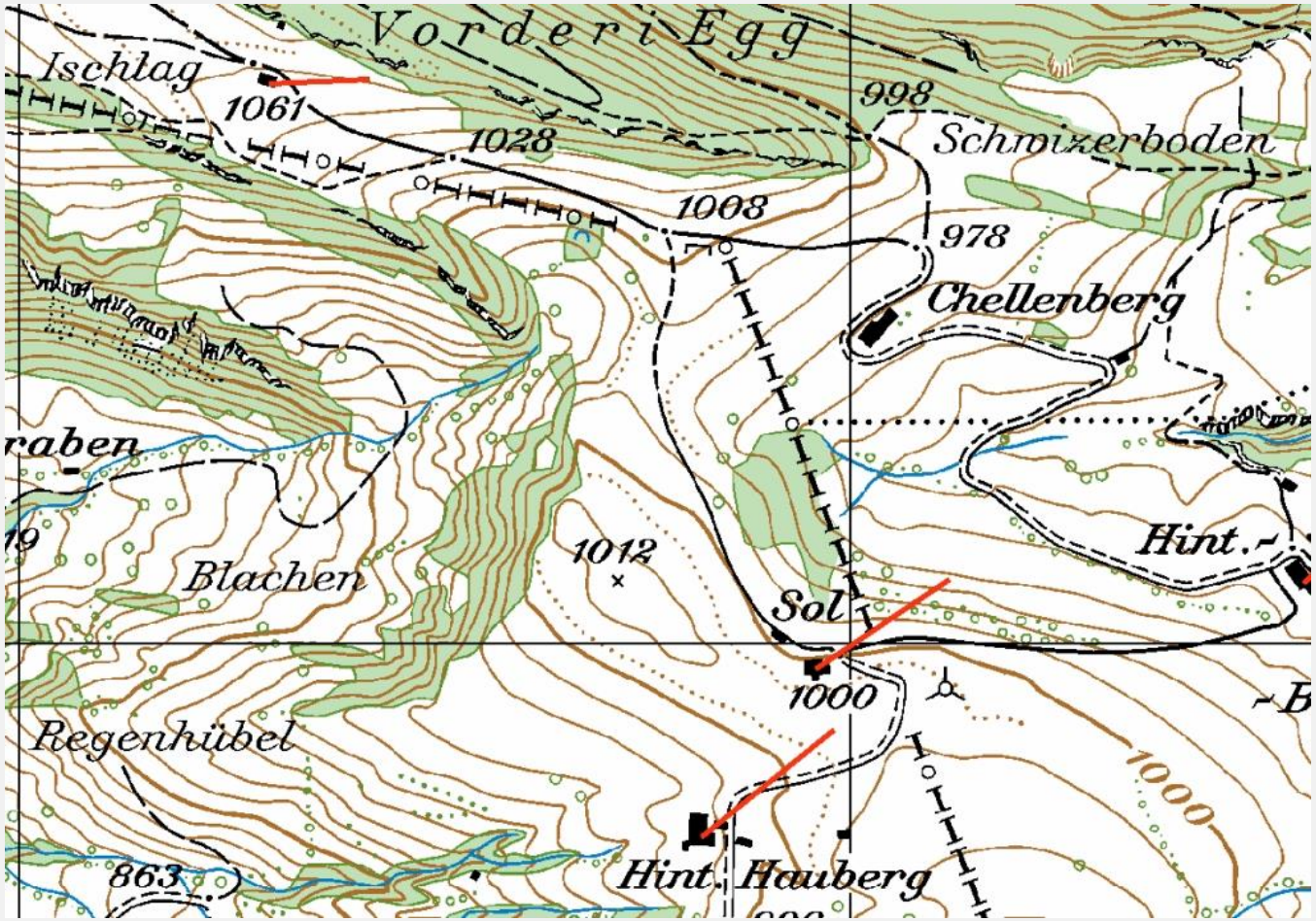



Was this the house that was surveyed by Meyer in 1680?

This point must be changed in the new system

Check of every point differing > 3*s0

# Second step: Transformations and checks






Check successful



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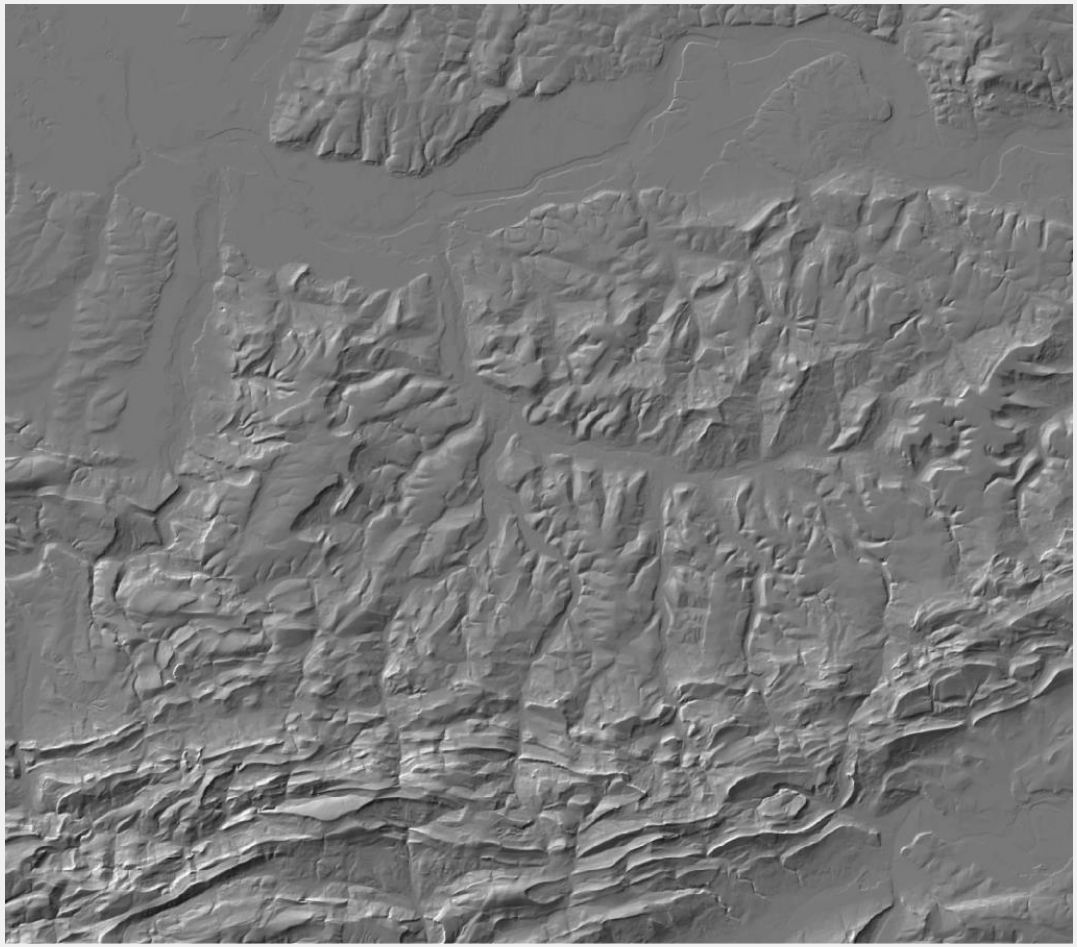
# Second step: Accuracy of the large map



Reliefschattierung DHM25 © swisstopo

Relief information in
north-western Switzerland



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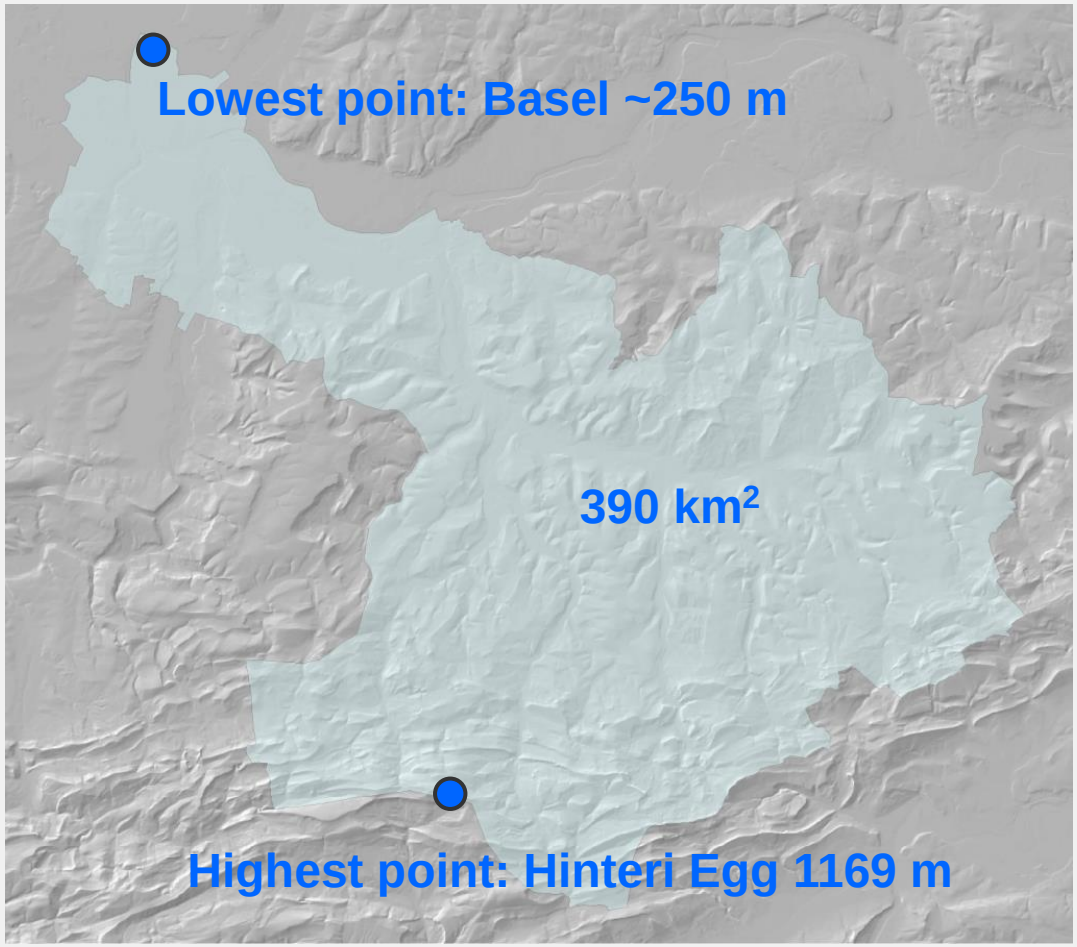
# Second step: Accuracy of the large map




Territory represented on the large-size map of Basel

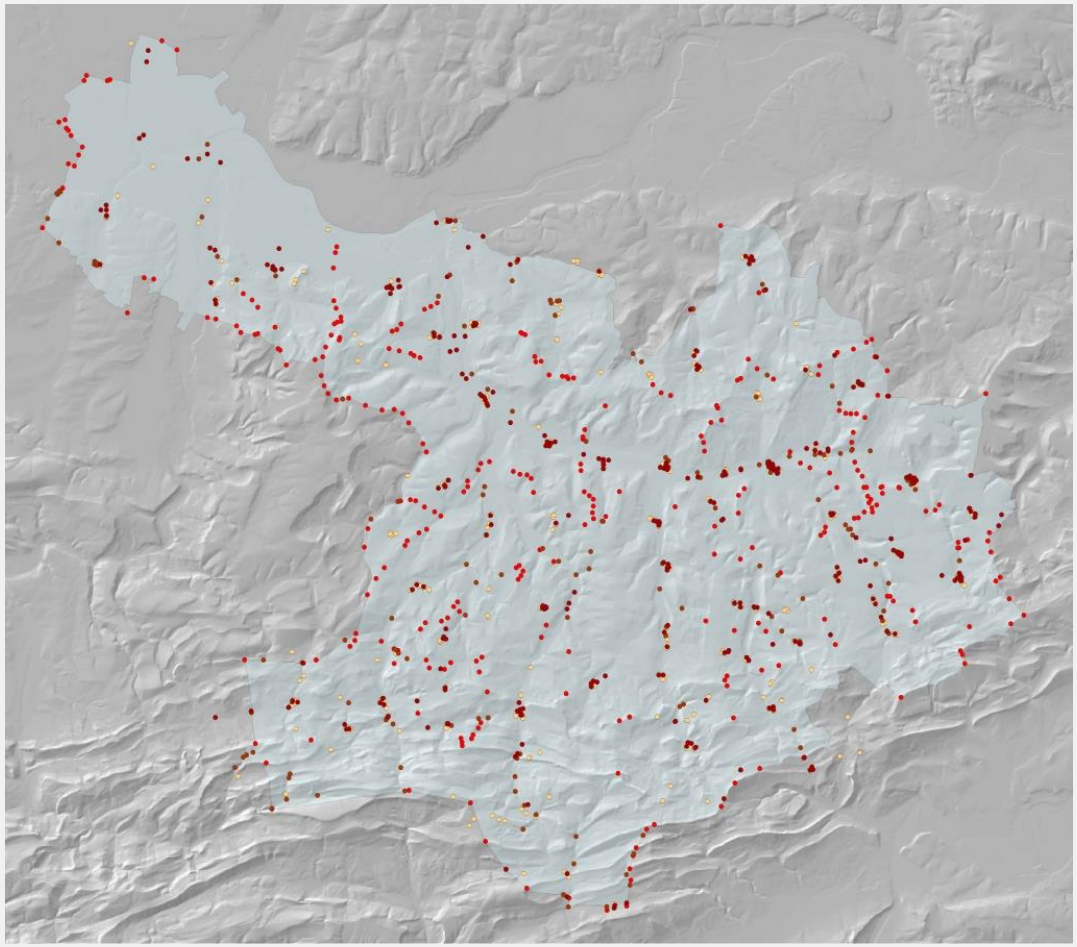
Hight difference between the lowest and the highest point: ~ 920 m

Reliefschattierung DHM25 / GG25 © swisstopo



DigiMeyer – the digitized large map of Basel

# Second step: Accuracy of the large map



1171 identical points

4 layers:
- boundaries
- hydrographic network
- road network
- buildings

Reliefschattierung DHM25 / GG25 © swisstopo



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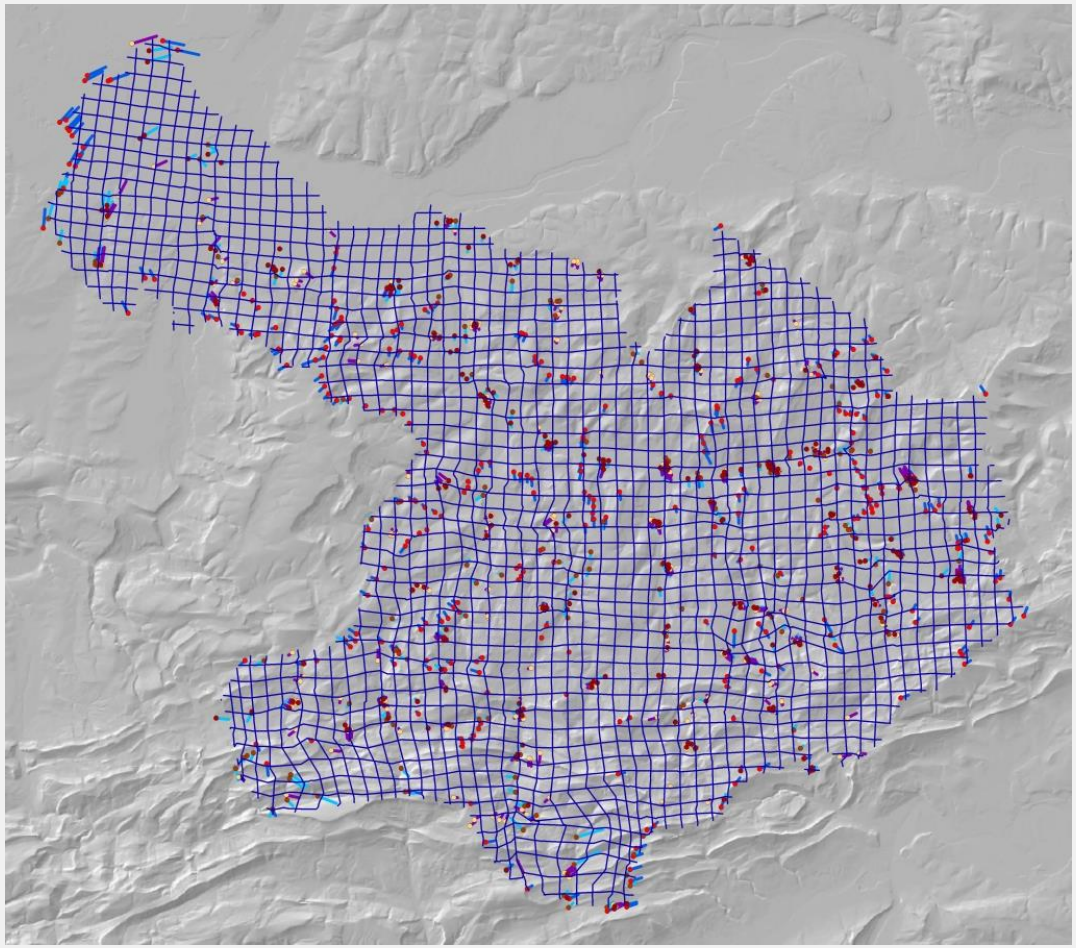
# Second step: Results for the large map

- Computed by: DiGrid
- 1171 identical points measured in 4 layers (boundaries, hydrological and road networks, buildings)
- Best fitting: 6-parameter affine transformation
- Scales: 10163 / 9987 (± 7 / ±9)
- Rotation:  -6.2° (± 0.04°) / Shear -0.28° (± 0.07°)
- a posteriori sigma of planar vector: 161 m / 16 mm
- Mid-plane error of one ident. point: 228 m / 23 mm

# Third step: Visualization in the new map



Distortion grid 500 m DiGrid

Differences at the 1171 identical points

The region around Basel shows a rotatation to the north-east

Irregularities mostly in regions with respectable elevation differences



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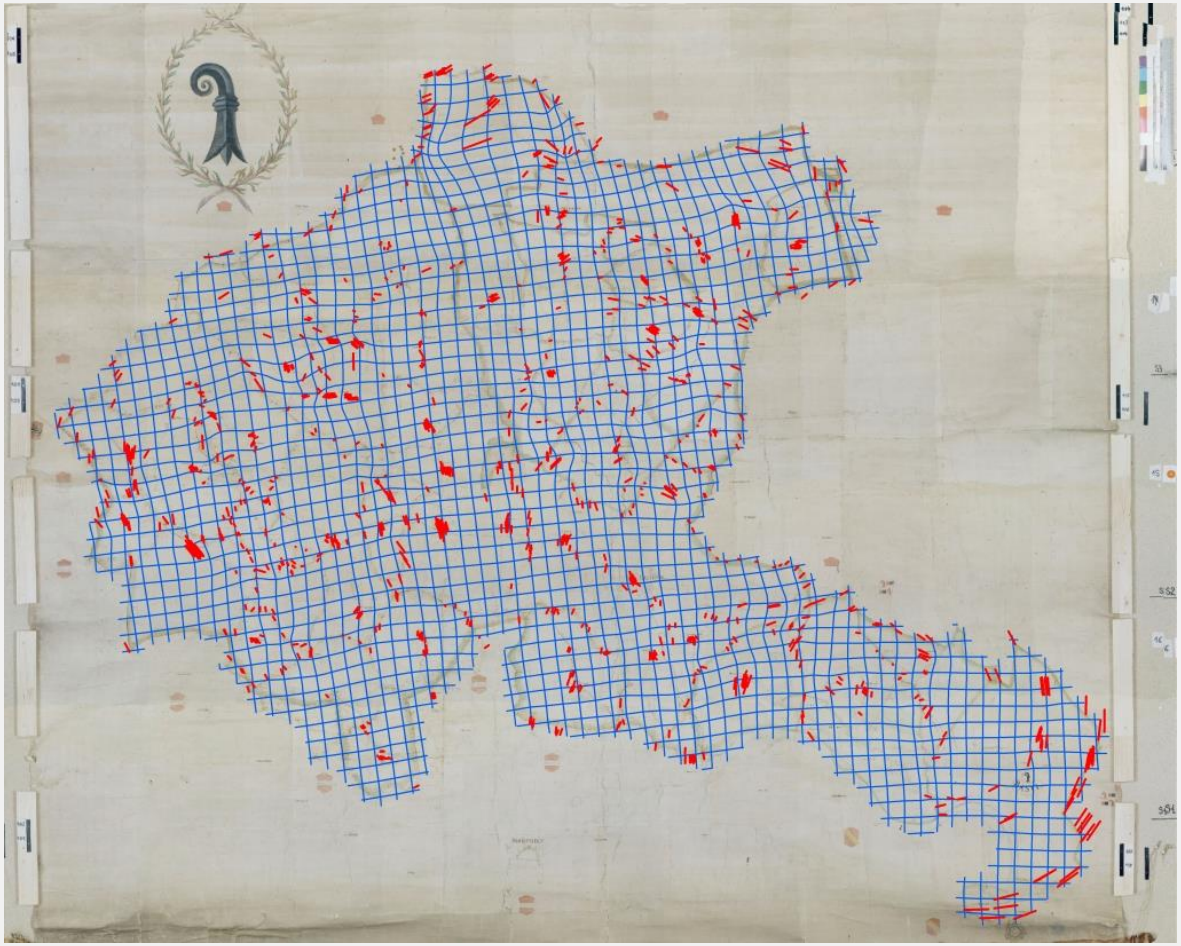
# Third step: Visualization in the old map



Distortion grid 500 m
MapAnalyst

Mr Meyer: Please accept my deepest respect for your extraordinary effort!



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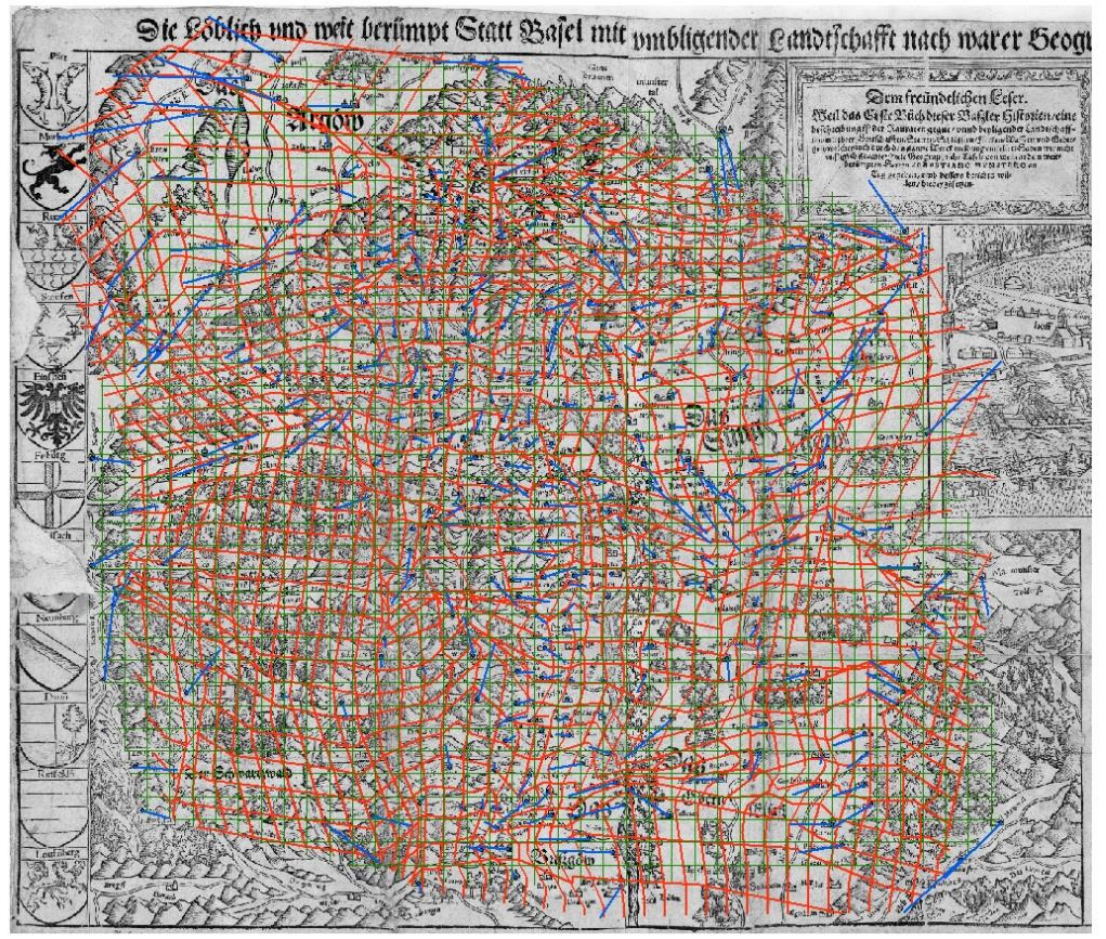
# Basel‘s big step to cartographic modernity




Software: DiGrid
© Dr. Jana Niederöst

Reference:
Sebastian Münster’s
Basel map from 1538

**Mid-plane error of one of 328 identical points:**

**2602 metres in reality**

**10 millimetres in the map**



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# Open questions (work in progress)

- Quality of ortho-rectification has to be checked
- Probable software error in the matching process
- New version of ortho-mosaic of the old map
- Check of the coordinates in the old map
- Eventually distortion analysis with more sophisticated mathematical models
- Research of the quality development from the 16$^{th}$ to the end of the 19$^{th}$ century.

# Conclusions

- I would like to encourage all map librarians and archivists to support such digitizing projects
- Please do not fear your investments
- You will protect your analogous maps by making them available in digital form, also the large ones!
- This allows researchers to look at very old works with modern eyes
- Conclusion for Basel: This territory was surveyed very early in an extraordinary good quality!
- Sebastian Münster had competend successors

# Thanks to: the DigiMeyer team



DigiMeyer – the digitized large map of Basel

# Thanks to: the program developers



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# Thanks to …

- Paper selection committee
- To everybody who contributed in whatever form to this presentation
- And to all of you for your attention!