DEM of the Top of The Bedrock of Northern Switzerland

Lost Valleys and Hidden Mountains

• The Origins: Civil Engineers Interest in the Bedrock.
• The Age of Discovery: Early Compilations of "Overdeep" Valleys.
• The Industrial Revolution: the DEM Project:
  - Initiation and Concept
  - Methods evaluated and used
  - Results and Quality control
• The Near Future: Application and further development of the DEM.

Peter Jordan, Böhringer AG Oberwil and Basel University (Switzerland)

Lenk, 12. 2. 2008
The Origins

• The position of bedrock and its spatial (3D) distribution is essential in
  - groundwater engineering: capture well construction, transmissivity
  - civil engineering: foundation and stability of buildings, costs
  - underground engineering: portal zone, crossing valleys
  - geophysical engineering: seismic sounding travel time calculations
  - hazard engineering: seismic site effects
  - mining engineering: overburden

• Generallz local and specific data acquisition and assessment
The Age of Discoveries

• Impetus
  - Understanding of complex, hardly predictable bed rock surface
  - Search of changes in erosion regime (Neotectonics)
  - Explanation of unexpected depth of bed rock below valleys

• Regional Compilations
  - maps of loose and bedrock characteristics ("Baugrund"; city scale)
  - maps of groundwater basins (small region scale)
  - maps of presumably tectonically active zones (small region scale)
  - maps of the "over deepened valleys" (regional scale)
The Age of Discoveries

• Impetus
  - complex bedrock surface
  - Neotectonics
  - deep old valleys

• Regional Compilations
  - maps of loose and bedrock characteristics ("Baugrund"; city scale)
  - maps of groundwater basins (small region scale)
  - maps of presumably tectonically active zones (small region scale)
  - maps of the "overdeep" valleys ("übertiefte Täler", regional scale)

Wildi (1984)
The Age of Discoveries

- Database
  - Boreholes
  - Outcrop evidence
  - Seismic sounding

- Techniques
  - hand made isoline sketch

Pugin (1986)
The Industrial Revolution

Early purely technocratic approaches …
… based on borehole-Database …
… interpolation of point data by computer codes (Spline, IWD, Kriging, Nat.N.)
But what might be good for weather, hydraulic heads or pollution …
… is definitively not appropriate to bedrock surface (even with dense database) …
… due to the lack of genetic input concerning fluvial or glacial erosion.
The Industrial Revolution
- The DEM Project

• Initiation
  - **Integral view** of the bedrock surface including lost or over deep valleys and hidden elevations but also the **fringe regions** and the **outcrop areas**
  - accurate data base in a 1:25'000 scale for **GIS-evaluation**

• Concept
  - **Compilation** of all **existing** regional and local **maps**
  - Collecting of all accessible **bore hole** information (about 15'000)
  - Integration of all published geological maps (**outcrop**)
  - compatible with Swiss survey land surface elevation model **DHM25** and DEM of geological surfaces an discontinuities.
The Industrial Revolution
- The DEM Project

- Methods evaluated
  - TIN vs. DEM
  - Interpolation codes:
    (Spline, IWD, Kriging, NatN, ANUDEM)

- The Workflow
  - Hand design of Isolines using all GIS facilities
  - Definition of valley axes
The Industrial Revolution
- The DEM Project

- Methods evaluated
  - TIN vs. DEM
  - Interpolation codes:
    - (Spline, IWD, Kriging, NatN, ANUDEM)

- The Workflow
  - Hand design of Isolines using all GIS facilities
  - Definition of valley axes
  - ANUDEM / Topo-to-Raster
  - Postprocessing

Slartibartfast, designer of planets, awarded for having created the Norwegian coast line.

The bedrock surface is the result of multiple phases of fluvial and glacial erosion.
The Industrial Revolution
- The DEM Project

• Methods evaluated
  - TIN vs. DEM
  - Interpolation codes:
    (Spline, IWD, Kriging, NatN, ANUDEM)

• The Workflow
  - Hand design of Isolines
  - Definition of valley axes
  - ANUDEM / Topo-to-Raster
  - Postprocessing
The Industrial Revolution

The DEM Project

- Methods evaluated: TIN vs. DEM
  - Interpolation codes:

The Workflow

- area-wide design of continuous isolines
- Definition of valley axes
- ANUDEM / Topo-to-Raster
- Postprocessing
Designing bedrock surface has some affinities to forensic plastic surgery … in a reversed way, i.e., from skin to skull.
Collecting and placing information

bedrock reached
not reached
outcrop
Filling gaps between data points

Typical equidistance 10 to 15 m
additional lines when needed
or when borehole data are dense

Defining valley axis
Interpolating the surface

Modellisation using only isolines and axes (i.e. NO borehole data)
Consideration of outcrop area
Quality control using bore hole data
(Visualisation of differences between DEM and borehole evidence)

model vs. reality

borehole data used / not used in interpolation
Würm-Glacification Interstadium
(50'000 years ago, before LGM)
(Graf, 2003)

- Ancient Rhine-Valley abandoned

- Formation of the today "Old Rhine Valley"

- River Rhein swapt to ancient Glatt-Valley

- Abandoned Glatt-Valley

- River Thur is going to swop to ist actual bed.

- River Töss has swopped to actual Töss-Valley

Quality control by comparison with landscape history concepts
The final DEM
(with actual water courses)
Digital Elevation Model DEM
Precision: 0.1 m
Raster / Pixel: 25 m x 25 m
Concordant with Swiss Coordinates
and Landsurface DHM of Swisstopo
actually 8126 x 4776 Pixel
The Near Future

• Applications (Examples)
  - Visualisation of Landscape Development
  - Distribution of Loose Rock Thickness
  - Calculation of Loose Rock Volume
  - Element of geological / geomorphic 3D-Simulations

• Conclusions

• Further Development
Bedrock surface DEM (Isolines and Hillshade)

Former Rhine Valleys

Rheinfell

Other Old Channels
Thickness of Loose Material in meter (classes >25, > 50, > 100, > 150 m etc.)

Schaffhausen
Munot
Klettgau
Visualisation of curiosities on the west bank of Lake Zurich

The Limmat - Reuss Connection

ancient water courses
actual water courses

Crossing Valleys near Urdorf

... now filled with up to 400 m loose rock.
Comparison of "overdeep" valleys and swell levels
Total Test Area: 204.2 km²
Volume of Loose Rock: 19.84 km³
The DEM Bedrock Surface as a base for 3D Visualisations

GIS-based Art Work

Fence Diagramm along Seismic Lines

Block Diagramm
The Near Future

• Conclusions
  - Successful attempt to Model the Bedrock Surface of N Switzerland
  - Results justify Time Consuming Elaboration
  - Multiple Application Possibilities from Visualization to Calculation
  - Quantification replaces Estimations, e.g., Regional Loose Rock Volume

Further Development

A Norway-like "Coast Line" near Berne: my Homage to Slartibartfast
The Near Future

• Further Development
  - Continuous "Inner Improvement"
    within the actual Model Area
  - **Extension** in the Berne Area
    by Berne University
  - Open to **Further Work**
    in accordance with the Owners: the
    Swiss Office of Topography and our
    customer, which does not want to be
    mentioned here, but to which we owe
    great thank for generous support.