Lecture Overview

- Definition: geomorphology
- Geomorphic mapping
- Review: Landslide terminology & classification systems
- Characteristics of landslides
- Mapping of landslide types
- Examples of geomorphic mapping in landslide studies

Linkages

Geomorphology is the science of relief forms, forming materials and the changing processes.
Geomorphological map Bildudalur (NW-Iceland)

Soil creep / solifluction

Assumption: 25mm/yr with 0.5m

Example: Geomorphic mapping in the Turtmann valley, Switzerland

Otto & Dikan, 2004
### Example: Geomorphic mapping in the Turtmann valley, Switzerland

#### Thematic components of the geomorphologic map of the Turtmann valley

<table>
<thead>
<tr>
<th>Thematic layer</th>
<th>Temporal scale</th>
<th>Map legend symbol</th>
<th>Information source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geomorphic Process</td>
<td>Activity in the last 5 years (red)</td>
<td>Point symbols (red or black)</td>
<td>Field observation, state of activity according to indicators (see text)</td>
</tr>
<tr>
<td></td>
<td>No Activity in the last 5 years (black)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singular Landform</td>
<td>Partly specified</td>
<td>Line or point symbols</td>
<td>Field observation</td>
</tr>
<tr>
<td>Geomorphography (neps and troughs of slopes, valleys, and drainage ways)</td>
<td>Not specified</td>
<td>Line symbols</td>
<td>Field observation, analysis of DTM and topographic maps</td>
</tr>
<tr>
<td>Process Domain</td>
<td>All scales (active and past processes)</td>
<td>Coloured polygons</td>
<td>Field observation, process recognition, material properties, inferring of past processes based on landform geometry and material</td>
</tr>
<tr>
<td>Hydrology/Glaciology</td>
<td>Not specified</td>
<td>Line symbols and polygons</td>
<td>Field observation, topographic maps</td>
</tr>
<tr>
<td>Subsurface Material</td>
<td>Not specified</td>
<td>Hatched polygons</td>
<td>Field observation</td>
</tr>
</tbody>
</table>

*Types of activity: continuous, intermittent, episodic, singular

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**Example: Qualitative sediment flux model of the Brändjútállí hanging valley**

![Qualitative sediment flux model](image)
Example: Geomorphic mapping in the Turtmann valley, Switzerland

Otto & Dikau, 2004
Example: Geomorphic mapping in the Turtmann valley, Switzerland

Otto & Dikau, 2004
Example: Geomorphic mapping in the Turtmann valley, Switzerland

Otto & Dikau, 2004
Example: Geomorphic mapping in the Turtmann valley, Switzerland

Example: Sediment storage - Rain valley, Germany
Linking storage – process / Activity of storages

Geomorphic mapping in landslide studies
Landslide terminology

- Crown
- Main scarp
- Top
- Head
- Minor scarp
- Main Body
- Foot
- Tip
- Toe

Surface of rupture
Surface of separation
Zone of depletion
Zone of accumulation
Depletion
Depleted mass
Accumulation
Flank

Adopted from Cruden & Varnes, 1996

Landslide classifications

- **Material**: Rock, Soil, Lithology, structure, Geotechnical properties
- **Geomorphic attributes**: Weathering, Slope form
- **Landslide geometry**: Depth, Length, Height etc.
- **Type of movement**: Fall, Slide, Flow etc.
- **Climate**: Tropical, Periglacial etc.
- **Water**: Dry, wet, saturated
- **Speed of movement**: Very slow, slow etc.
- **Triggering mechanism**: Earthquake, rainfall, etc.
Landslide classifications (1/3) – Sharpe 1938

- Material: earth, rock
- Movement: flow, slip
- Velocity: slow to very rapid
- Water/ice content

Landslide classifications (2/3) – Varnes 1978

- Material: bedrock, debris, earth
- Movement: fall, topple, slide, flow, complex
- Secondary: water content, velocity
Landslide classifications (3/3) – Wieczorek 1984

YESF:
Y = Dormant-Young
E = Earth
S = Slide
F = Flow

Landslide characteristics: Morphology
### Landslide characteristics: Vegetation

<table>
<thead>
<tr>
<th>Vegetation Characteristics</th>
<th>Block Diagram</th>
<th>Plan view</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Disorder and partly dead vegetation</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>9. Disrupted vegetation cover across the slope and coinciding with morphological steps</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>10. Less dense vegetated areas aligned and with lighter tones</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>11. Differences in vegetation inside and outside of the landslide</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>12. Change in vegetation related with drainage conditions</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
</tbody>
</table>

### Landslide characteristics: Drainage

<table>
<thead>
<tr>
<th>Drainage Characteristics</th>
<th>Sketch</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Disarranged drainage</td>
<td>Drainage lines broken</td>
</tr>
<tr>
<td>14. Anomaly in drainage pattern</td>
<td></td>
</tr>
<tr>
<td>15. Zones of stagnated water</td>
<td>Ponds formation</td>
</tr>
<tr>
<td>16. Seepage zones or well appearance</td>
<td>Darker tone leading to drainage line</td>
</tr>
<tr>
<td>17. Excessively drained masses (especially dried out landslide bodies)</td>
<td>Light phototones</td>
</tr>
</tbody>
</table>
### Landslide characteristics: Active vs. Non-active

<table>
<thead>
<tr>
<th>Non-Active</th>
<th>Active</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scarp body and cracks with rounded edges</td>
<td>Scarp body and cracks with sharp edges</td>
</tr>
<tr>
<td>Vegetation is high within the landslide and non-eroded areas</td>
<td>Disarranged drainage system, presence of pond and unnatural expressions</td>
</tr>
<tr>
<td>Well-developed drainage system</td>
<td>Secondary mass movement on scarp flanks</td>
</tr>
<tr>
<td>No secondary mass movements on scarp faces</td>
<td>Secondary mass movements are disrupted</td>
</tr>
<tr>
<td>Stabilization measures visible and not disrupted</td>
<td>Stabilization measures are disrupted</td>
</tr>
<tr>
<td>Depositional and cracks infilled with material</td>
<td>New cracks developing above the upper scarp</td>
</tr>
</tbody>
</table>

### Mapping Landslide Types

- **Slides**
  - Body or boulders by blocks
  - Landslide blocks are recognizable
  - No destruction of blocks or flow below
  - Cardinals vary in boulder
  - Intermediate to upper cracks present

- **Flowslides**
  - Body or boulders by blocks
  - Landslide blocks in the upper part visible
  - Blocks may deform into block-like draining
  - The body generally is larger than the blocks
  - Body is still present within upper area

- **Flows**
  - No landslide blocks are visible
  - Mass movement took place as a flow
  - Usual precursors at genre of changes
  - Flow may extend far beyond upper area

- **Debris avalanches**
  - Rapid movement of material away from the upper area
  - Landslide bodies found down via tilt shift at upper location
  - Occurs at steep depths
Mapping Landslide Types

Field methods – topographic measurements

- Tachymeter
  - Petrahn 1996
  - Keaton & de Graff 1996
  - Großmann 1983
Field methods – topographic measurements

- Tachymeter

Natural Hazards/Risk & Geomorphology

Geomorphologic mapping
- Identification of distributions of processes
- Estimation of temporal occurrence
- Analysis of material
- Assessment of sediment storage
- Basic information for process modeling

Geomorphologic process studies
- Verification of assumptions
- Estimation of sediment production
Field methods – topographic measurements

- GPS

Period: Okt 01 – Mai 02
- Okt-Dez: no movement
- Jan: 3cm – snow melting
- Feb: ~30cm – heavy rainfalls
- March: no movement
Geomorphic mapping

- Legend of Terhorst (2001)
Geomorphologic mapping

Geomorphologic mapping in landslide studies

General geomorphological mapping with focus on landslides
1:50,000
(Kallinich 1999)

Only cuesta and landslide heads were mapped
Geomorphic mapping in landslide studies

Geological profile derived from geomorphological mapping
Geomorphic mapping in landslide studies

Mössingen-Öschingen

Legend:
- Surveying points
- Inclinometer
- Damaged building
Geomorphic mapping in landslide studies

Elements at risks - Houses
Elements at risk – Classified regions

Mössingen-Öschingen

Elements at risk – Classified regions

Mössingen-Öschingen
Mapping of Rockfall impact – (1/2)

Mapping of Rockfall impact – (2/2)

Wieczorek et al. (2000)
Conclusion

- **Form – Geomorphometric features**
  - Approximation of age
  - Topographic measurements (Tachymeter, GPS)
- **Material – Near subsurface material**
  - 1m drillings
- **Process domains**
  - Dominant process – spatially distributed
  - Grade of activity

References

References

- Varnes, D.J. 1978: Types of slope movement.